USCHENBERGER'S SERIES.

BOOKS OF NATURAL HISTORY.

ELEMENTS OF ANATOMY

AND

PHYSIOLOGY:

PREPARED FOR THE USE OF

SCHOOLS AND COLLEGES,

BY

W. S. W. RUSCHENBERGER, M.D.

U. S. Navy; Fellow of the College of Physicians; Hon. Member of the Philadelphia Medical Society; Member of the Academy of Natural Sciences of Philadelphia, &c. &c.

FROM THE TEXT OF

MILNE EDWARDS, AND ACHILLE COMTÉ,

PROFESSORS OF NATURAL HISTORY IN THE COLLEGES OF HENRI IV, AND CHARLEMAGNE.

WITH PLATES.

PHILADELPHIA:
LIPPINCOTT, GRAMBO, & CO.,
SUCCESSORS TO
GRIGG, ELLIOT & CO.,
No. 14, NORTH FOURTH ST.
1852.

Monroe & Soemmering reckon 260 bones; & [illegible] who take the number at 253, include the patellae, ossa sesamoidea, os hyoides as 5 pieces sternum & 23. coccyx as 4 & the small bones of the ear. If however, we omit those just enumerated, as being either accessories connected with the several organs the whole number of pieces found in the ordinary skeleton will be 197, as follows.

The spinal column, properly so called consists of 24 vertebral, the sacrum & the coccyx . . . . . 26.

The skull is made up of 8 cranial bones viz. 2 frontal, 2 parietal 2 temporal the frontal & the sphenoid & ethmoid & of 14 facial . . . 2 nasal, 2 lachrymal 2 superior maxillary & 2 palatal 2 turbinated, one vomer & the inferior maxillary bone 22

The ribs are 24 in number (twelve on each side), with the sternum 25.

The two superior extremities consist each of a clavicle & scapula, humerus, radius & ulna, 8 carpal bones, 5 metacarpal & 14. in the digital ones 66

The 2 inferior extremities comprise each, one pelvic bone (innominate) 1 femur, tibia, & fibula, seven tarsal bones, 5 metatarsal & 14 digital. 60

197.

THE SKELETON.

See page 97 for explanation.

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CHAMBER OF THE BOARD OF CONTROLLERS,
OF THE
PUBLIC SCHOOLS.
FIRST SCHOOL DISTRICT OF PENNSYLVANIA.

Philadelphia, December 14th, 1841.

At a meeting of the Board of Controllers of the Public Schools of the First School District, of Pennsylvania, held at the Controllers' Chamber on Tuesday, December 14th, 1841, it was

RESOLVED: That the "First Book of Natural History, prepared for the use of Schools and Colleges, by W. S. W. Ruschenberger, M. D.," be introduced into the Grammar Schools, to be used therein at the discretion of the Visiting Committees.

THOMAS B. FLORENCE, *Secretary.*

From the minutes.

Printed by T. K. & P. G. Collins.

PREFACE.

The original text of this volume forms the first of a series of First Books on Natural History which were arranged and published by men distinguished in science, under the direction of the "ROYAL COUNCIL OF PUBLIC INSTRUCTION OF FRANCE," for the Use of Schools and Colleges of that country. These First Books or Primers are seven in number, and embrace the following subjects, each complete in itself.

No. 1. General Notions on Physiology, and Animal Mechanism.

No. 2. Mammalogy, or the Natural History of Mammiferous Animals.

No. 3. Ornithology, or the Natural History of Birds.

No. 4. The Natural History of Reptiles, Fishes, and Mollusca.

No. 5. The History of Insects, of the Crustacea, Arachnides, Annelides, and Zoophytes.

No. 6. Botany; and

No. 7. Geology.

The great care which has been bestowed in the preparation of these Primers, and their almost unparalleled popularity in France, hundreds of thousands having been sold in the course of a short time, has led me to offer to the public, the first of the series: Should this little work be favourably received, the other primers will be prepared in a similar style and offered to the American public.

The work does not pretend to be more than a mere outline, and is chiefly designed as an introduction to the study of natural history; but it treats sufficiently of Physiology and animal mechanism, to be well adapted to the use of schools, as well as for young persons, and even others who have not the opportunity or inclination to study the subject in professional treatises. Each branch of the subject is treated of in as few words as perspicuity will

permit. The reader is led on from point to point, and is informed in the progress of the work of all that is requisite to enable him to understand generally, the phenomena of the circulation of the blood, respiration, digestion; and the structure, and mode of operation of the several senses are clearly set forth.

One considerable objection to the several highly meritorious works which have been, within a short period, presented to the public on popular physiology, namely the price, being too expensive for general use in common schools, has been obviated in this.

In order to render this little book more complete for the use of schools, I have added, at the foot of each page, questions upon the text, which in many instances serve to illustrate it, and also a short glossary of such words as are used in a technical sense. When the character of the plates, and the matter of the work, are taken into consideration, with the very small sum for which the whole is afforded, I hope it will meet with a proper reception.

Philadelphia, June 1, 1841.

PREFACE TO THE FIFTH EDITION.

The necessity for a fifth edition of this volume, in less than one year after the publication of the first impression, is strongly indicative of the estimate set upon the work by the public. The high praise which has been bestowed upon it, by those whose opinions are most valuable, and the favor it has met in various parts of the United States, have induced the publishers, (at considerable expense) to add engravings in the body of the book, illustrative of the text, which has been carefully revised.

Though designed as a book for schools and colleges, it will be found well adapted for the general reader; and students of medicine will find it of use, especially in the early part of their professional studies.

With the view of assisting the reader in understanding and remembering the words used in a technical sense, their etymologies have been added in the glossary. Many of these words are derived from the Greek; and, in as much as all persons who are in pursuit of knowledge, are not acquainted with that language, the words from it have been printed in *italics*, in preference to using the proper Greek characters; and the omega, where it occurs has been designated thus, (*ō*).

I wish those teachers, (who honor me by using this, or any other one of my series of First-Books), to clearly understand, it is not my design that the questions at the foot of the page shall be answered by repeating the text from memory; the pupil should be able to give the facts in his own language, and show he comprehends the subject:—I wish my readers to obtain knowledge, definite ideas of the subjects treated, and not to acquire merely the words that are descriptive of them.

It is hoped that nothing is now wanting to render this little work a clear concise, and axiomatic account of Physiology and Animal Mechanism, and that it will sustain the favorable opinions which have been kindly expressed of it.

W. S. W. R.

Philadelphia, May 15, 1842.

We regard the introduction of this work, into our public schools, among the highest compliments it has received, for we feel sure that the gentlemen who constitute the Committee for selecting books, possess too much discernment and general knowledge, to pass favorably upon works of inferior pretensions. The following gentlemen composed the Committee for selecting books for the use of Public Schools.

George M. Wharton, Esq.
Thomas H. Forsyth, Esq.
George Emlen, Jr., Esq.
Francis Lyons, Esq.
John C. Smith, Esq.

INTRODUCTION.*

Natural History, which may be defined the intelligent contemplation of the works of God, is in a manner the most certain and the most noble subject, that can occupy the mind of man. In it alone, human genius is in full possession of certainty. Philosophy, politics, history, and morality itself, are subject to the intellectual revolutions of wavering humanity; but the facts of the Creation are as invariable as God, and the analysis obtained from a plant or an insect, marks its demonstration with the seal of eternal truth.

The double effect of the study of Natural History is to impart certainty to the mind, and religion to the heart. The creation is as a visible ladder by which man ascends towards the invisible Creator.

Natural History, the science which is the mother of all sciences, embraces the whole world; physical knowledge, mathematical knowledge, are all comprehended in its domain; and, as we have just said, the teachings of morality, here mingle of themselves, without any effort, with thoughts of religion.

It has been said that Natural History should be the only reading-book of the people; I would add, it should be the first book of childhood. Of all the means which we may successfully employ for awakening the intellect of young people, there is none, the results of which are more certain or more durable than curiosity; the desire to know is as natural as reason; it is vivid, and active at every period of life, but it is never more so than in youth, when the mind, destitute of knowledge, seizes upon all that presents itself with avidity, and willingly gives the attention and study necessary to know, and very naturally contracts the habit of reflection and of being occupied.

It is not the labours of the learned that are to be brought to the attention of infancy, but a study of nature, to comprehend which requires scarcely anything but eyes and which consists in examining carefully the objects of nature, in order to admire their beauties, without diving into their hidden causes. Children are capable of this study, for they have eyes, and they have curiosity; they desire to know, and they are inquiring. A garden, a field, a palace, all is an open book for them; and they should be taught to read in it. "It is inconceivable," says Rollin, "how much children might learn if we could profit by the opportunities which they themselves afford us." To seize upon these opportunities should be a desideratum with instructors and parents.

*Extracted from the "Atlas Methodique," of Natural History.

In this, then, behold what nature was without man. . . . But if man appear, if, to recur to the brilliant thought of Bacon, "*man is added to nature*," then Creation has a voice, a value, a sense. Of the innumerable crowds of animals, and of plants that share between them the domain of the earth, and of the marvellous events that renew the face of things, man has become the master and the historian; all have an equal right to his admiration, all are equally subjects of his study. From the almost imperceptible mould to the colossal productions of the vegetable kingdom, from the microscopic animalcule to the elephant and the whale, from the atom of sand to the summit of Atlas, he interrogates, he comprehends, he explains them all. Imagination is no longer at the expense of inventing brilliant pictures; truth alone strikes his mind and elevates his soul, and, in place of the confused reveries inspired by chaos, appears a science of wisdom, of reason, and of order, which, in a word, is NATURAL HISTORY.

The individual who enters a field, or strolls upon the bank of a stream, or roams through the forest, if he comprehend the elements of Natural History, may read a pleasant story and acquire information, at every step, from the great Book of Nature, which every where lies open wide before him; but if ignorant of Natural History, this magnificent and varied work is to him no more than is a printed volume to one who never learned a letter. Natural History not only affords us the means of endless amusement, but teaches us to discover the riches of the earth, and to gather from them the means of ameliorating and improving the condition of man.

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GENERAL NOTIONS
ON
NATURAL HISTORY.

LESSON I.

The Natural Sciences and their Divisions—Definition of Zoology—General knowledge necessary to its successful study—The structure of animals, and enumeration of their principal organs—Classification of the functions of animals.

1. The Natural Sciences have for their object, the study of those beings, the assemblage of which compose the universe.

This study is divided into many distinct branches; but these branches are all so linked, one to the other, as to afford a mutual support.

2. The different branches of the Natural Sciences are: Physics, Chemistry, Astronomy, Meteorology, and Natural History.

3. The name *physics* is given to that science which embraces the consideration of the general properties of matter; which studies the motions of bodies, as well as Heat, Light, Electricity, Attraction, and which applies the knowledge thus acquired to the explanation of the great phenomena of nature.

4. *Chemistry* has for its object, the knowledge of the intimate composition of bodies, and the various combinations which may be made from them. It teaches us what are the forming elements of different bodies, and how these elements, by combining in various ways, may give rise to other bodies, and enables us to understand the properties of all these substances.

5. *Natural History*, taken in its most general acceptation, should include the study of the form, of the structure, and of the mode of existence of all the bodies of nature, individually considered; but, by common consent, the domain of this science is

1. What is the object of the natural sciences?
2. What are the different branches of the natural sciences?
3. What does the science of physics embrace the study of?
4. What has chemistry for its object? what does it teach?
5. In the most general acceptation of the term, what is included under the name of natural history?

more limited, and all that has not a direct relation to the physical history of our globe and the beings spread over its surface, is excluded. Consequently, it does not embrace the study of the stars, nor of meteors, nor even of the air which surrounds our globe; or, in other words, it comprises neither astronomy nor meteorology.

6. *Astronomy*, if we may so express ourselves, is the natural history of the celestial bodies; by the assistance of observation and calculation, it applies the general laws of physics to the study of the phenomena which the celestial bodies present, and thus determines their form, their volume, the distance which they are separated from our globe as well as from each other, and the movements which they perform in space.

7. *Meteorology* is in some measure the natural history of the atmosphere; it inquires the origin of thunder, of rain, of hail, of the dew, of falling or meteoric stones, (aërolites), and of the various meteors which appear in the heavens.

8. Natural History properly so called, we repeat, extends its domain over the structure of our globe, and over all the beings found upon its surface.

9. These beings are separated into three groups or kingdoms; the mineral kingdom; the vegetable kingdom, and the animal kingdom; in this way Natural History is divided into three branches:—

10. *The natural history of Minerals, and that of the terrestrial globe, which is formed of them, bear the names of* Mineralogy, *and* Geology.

11. *The natural history of Plants is called* Botany.

12. *The natural history of Animals is termed* Zoology.

It is the last of these which is to occupy our attention at present.

13. The study of animals, as well as the study of plants, is subdivided into three principal branches, according as they are considered in respect to:

1st, The characters which distinguish them one from the other, the climate they dwell in, their habits, &c.;

2nd, The internal structure of their bodies;

3rd, The play of their organs and the manner in which they respectively produce the various phenomena of life.

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6. What is Astronomy?
7. What is Meteorology?
8. What is Natural History properly so called?
9. Into how many kingdoms is Natural History divided? What are they?
10. What is Mineralogy? Geology?
11. What is Botany?
12. What is Zoology?
13. How is the study of Animals and Plants divided?

These three branches of the natural history of animals and of plants. constitute three sciences which are known under names of *Zoology*, (*or, when plants are referred to, descriptive Botany,*) *Anatomy*, and *Physiology*.

14. Anatomy *treats of the internal conformation of living beings:* it studies them by the aid of dissection, and acquaints us with the position, the form, and the structure of their organs. In as much as it embraces the consideration of either animals or plants, it constitutes two distinct sciences: *Zoological Anatomy, and Vegetable Anatomy.*

15. Physiology *is the Science of Life;* it teaches the use of different organs, and the manner in which these act, to produce the different phenomena, (that is, visible qualities), proper to living beings. Like Anatomy, it may have for its domain either the animal or vegetable kingdom, and it is consequently divided into *Animal Physiology*, and *Vegetable Physiology*.

16. It is easy to understand that, without the aid of Anatomy and Physiology, the profound study of natural history would be impossible. When we wish to obtain an exact idea of a watch, we do not limit ourselves to observing its exterior form, and to noticing the manner in which the hands turn; we open it, we examine every wheel, every chain, every spring:—we would separate them one by one, and study the relations which they have to each other, and we would seek to understand their use; afterwards, we should again put together all these pieces, and by re-establishing their mutual relations, restore what we had taken from them; that is, their movements and their play.

Now, what the watchmaker does to obtain exact knowledge of a watch, the naturalist does, as far as he is capable, to study an animal or a plant; by dissection he examines the interior of its body, separates the different organs, determines their relations, and studies their form and nature; then he observes their play during life, and, by making experiments, becomes acquainted with their uses. Unfortunately the naturalist cannot do all that the watchmaker does; he can destroy, but he cannot re-construct what he has deranged, and restore movement to organs which he has separated to study their structure—nevertheless, by anatomical investigation, by observation of the vital phenomena and by physiological experiments, he ascertains the mechanism of these

14. What is anatomy? what does it teach?

15 What is physiology? what does it teach? what is animal physiology? what is vegetable physiology?

16. Why is a knowledge of anatomy and physiology necessary to understand natural history?

complicated machines, and succeeds in satisfying ardent curiosity, which is one of the characteristic traits of superior intelligence.

No study can be more grand, or more interesting; in revealing what is extraordinary in animal organization, it leaves us filled with admiration at the sight of this infinite, this most astonishing work of the Creator.

Considered in their mechanical relations alone, the bodies of animals present us examples of complication and perfection, to which our best constructed and most perfect machines do not approach: here we find without number, models of ingenious contrivances, of which, the most successful labors of the architect or optician have produced but imperfect copies.

But these are the least of the wonders which the animal economy offers us. The forces, which put into action all the material springs of our body, are regulated and combined with a wisdom which is far beyond human science; and the more we contemplate the play of our organs, and the faculties with which they are endowed, the more we feel the necessity of recurring to the Superior Intelligence who has created this admirable production, and who has placed in it, a principle of existence and of movement.

To study with profit the particular history of different animals, it is necessary, as we see, to possesss some general notions of their anatomy and physiology; and it is this preliminary knowledge which is to engage our attention in the first of our course.

Of the general composition of Animal Bodies, and the functions performed by their different organs.

17 All living beings are formed of a union of solid and of liquid parts.

18. The solid parts are composed of small fibres and little plates, so arranged as to contain the liquid parts, in spaces left between them; they thus form textures or tissues of various kinds, and we give the name of *organization* to the disposition which the tissues assume.

19. Organized bodies, that is, bodies having an organization or mode of structure which we have just indicated, are the only living beings; because this internal conformation is necessary to the maintenance of life: therefore, non-organized or inorganic bodies, as stones, and metals are incapable of living.

17. Of what are living beings formed?

18. Of what are the solid parts composed? what is meant by organization?

19. What are organized bodies? Why are stones and metals incapable of living?

20. The different phenomena by which life manifests itself, are always the result of the action of some part of the living body; and these parts, which may be regarded as so many instruments, are called ORGANS.

21. Thus, an animal cannot move without the action of certain *organs* called muscles, or attain a knowledge of that which surrounds him except by the intervention of the *organs* of sense.

22. When several organs concur to produce the same phenomenon, the assemblage of instruments is termed an APPARATUS.

23. We say, for example, *the apparatus of locomotion* to designate the assemblage of organs which serve to transfer an animal from one place to another; and, *apparatus of digestion* to designate the assemblage of organs, by the assistance of which the animal digests its food.

24. The action of one of these *organs*, or of one of these *apparatus*, or the use for which they are designed, is called a *function*.

25. We say, therefore, *function of locomotion*, to designate *the action* of all the parts of the apparatus of locomotion; *the function of digestion*, to designate the *action* of the different parts which constitute the digestive apparatus; and *functions of the stomach*, *functions of the intestines*, *functions of the teeth*, &c., to designate the *uses* of these different organs. With man, as well as with all quadrupeds, birds and a majority of other animals, the organs, and the functions which the latter exercise, are very various.

26. Considered individually, the body of the majority of animals is divided into three principal portions; the *head*, the *trunk*, and the *members*, or extremities.

27. The *head*, which is not found with all animals, oysters for instance, is subdivided into two parts; the *cranium* or skull, and the *face*.

28. The *trunk* is composed also of two parts; the *chest* or *thorax*, and the belly or *abdomen*.

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20. What is meant by an organ?

21. Give an example of an organ?

22. What is an apparatus?

23. What are the examples of an apparatus?

24. What is a function?

25. Give examples of what is meant by the term function.

26. How are the bodies of animals divided?

27. Does every animal possess a head? What are the divisions of the head?

28. Of how many parts is the trunk composed? What are they?

29. In most of the animals at present referred to, the *members* exist in double pairs, and are distinguished as *superior*, or *thoracic*, and *posterior* or *abdominal*, or *inferior* members, or extremities. Certain animals, such as the whale, have only a single pair; others, such as serpents, have none at all, and others again have a considerable number; insects have three pairs of feet, spiders four pairs, crabs and lobsters five pairs, the wood-louse, or palmer seven pairs, and certain worms have as many even as five hundred pairs.

30. In all these animals, the body is enveloped on all sides in a resisting membrane, endowed with sensibility, which is termed the *skin;* it is secured from the inside, and its general form is determined by a solid frame, composed of a number of bones, called a *skeleton*, (*Frontispiece.*) Farther on we shall enumerate these bones, speak of their names and various forms.

31. The skeleton does not exist with all animals; oysters and snails for example are without it; and with others again, such as lobsters, the skin acquires an extreme hardness, and answers in place of this bony frame; but with all mammiferous animals, birds, reptiles and fishes, there exists a skeleton, arranged in a manner analogous to that of man.

32. Between this internal frame and the skin or external envelope, are found the muscles, which constitute what is commonly called *flesh*, whose function is to produce, by their contractions, all the motions which the animal performs; between these muscles are placed the vessels which carry the blood to different points of the body, the nerves which give sensibility, &c.

Within the head, and in the trunk we find also other parts.

33. The face presents several cavities, which serve to lodge the organs of sight, of smell, and of taste.

34. The cranium or skull is a sort of bony box, the interior of which is *filled* by one of the most important organs of the

29. In the animals at present referred to, how do the members exist? How are they distinguished? Have all animals the same number of members or limbs?

30. What is the skin? How is it secured? What is its form? What is the skeleton?

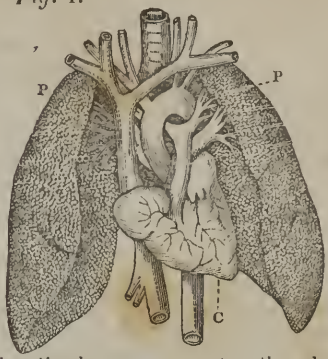
31. Does every animal possess a skeleton? What animals are without a skeleton? Is there any instance where the skin takes its place? What classes of animals have skeletons?

32. What are muscles? What is their function? What are placed between the muscles?

33. For what purpose are the several cavities in the face?

34. What is the cranium or Skull? What does it contain? Is it full? What is the continuation of the brain called? What is found on each side of the Skull?

Fig. 1.



body, the brain which is continued downward in a thick, whitish cord, called the spinal marrow. It descends along the back, and communicates with the principal nerves of the body. (*Page 73 fig.* 25.)

35. On cutting through the ribs and opening the bony cage, which anatomists call the *thorax*, and which we commonly call the chest or breast, we find the heart (c.) and lungs, (P.P.) (*Fig.* 1.) A fleshy partition, the *diaphragm*, separates the chest from the belly or *abdomen*, and in this latter cavity, are contained the stomach, the intestines, the liver, the spleen, and many other organs of less importance.

36. These different organs fulfil very various functions; some, such as the mouth, the teeth, the stomach, the intestines, and the liver, serve digestion; others, such as the lungs, (PP) are designed for respiration; others again, the heart, (C) for example, distribute to all the organs, matter necessary for their nourishment, and there are others again, the use of which is to enable us to appreciate tastes, and smells, to hear sounds, to see what surrounds us, to feel what touches us, and to transport us from place to place.

37. These functions, in spite of their diversity, tend to two principal objects, and are consequently divided into two classes: *the object of one class of functions is the preservation of the life of the individual, and are therefore denominated,* Functions of Nutrition; the others place the animal *in relation with* all that surrounds him, and, *consequently, are called* Functions of Relation.

38. The functions of nutrition, as their name implies, all serve *in imparting* nutrition *to* the animal, either by separating nutritive matter from the productions of the earth, by modifying this matter and by reducing it to a fluid or juice, *fit* to be admitted into the organs, or finally, by conveying into the substance of the organs this nourishing fluid, which, by its combinations, insures their maintenance and favours their growth. Consequently,

35. What is the thorax? What does it contain? What separates the thorax from the abdomen? What does the abdomen contain?
36. What is the use of these different organs?
37. What is the chief objects of all these various functions?
38. What is the object of the functions of nutrition?

digestion, respiration, and the circulation of the blood belong to this class of functions.

39. The *functions of relation*, are all those which place the animal in relation with the other beings of nature; they are principally the faculties of feeling in different ways, and of moving. By the aid of these functions the animal is enabled to appreciate the form, the colour, and the position of objects surrounding him; to hear the sounds which they make, to advance towards or retire from them, in a word, they serve to establish between him and the external world a variety of relations which are as numerous as they are useful.

40. The functions of nutrition are indispensable to the maintenance of life, and they are found, in a greater or less number in all living or organised beings, and for this reason they are called the *functions of organic life*, or *functions of vegetative life*.

41. The functions of relation, on the contrary, do not exist in all living beings; plants have them not; animals alone possess them, but, in loosing them they do not necessarily cease to live; during a part of their existence, they do not exercise them, and this state of repose of the functions of relation, constitutes *sleep*.

42. In consequence of these functions being peculiar to animals, they are also called the *functions of animal life*.

It is now very easy to state, in a few words, the most important differences which exist between vegetables and animals.

43. Vegetables are beings constituted for living, with the power of nourishing and reproducing themselves.

44. Animals are beings whose conformation enables them to live, to be nourished, to reproduce themselves, to feel, and to move.

The reader will now easily comprehend the difference between *organised* beings, as plants and animals, and *inorganic* bodies, as rocks and minerals, which do not possess the power of *nourishing* and *reproducing* themselves, the first and most important effects of living organization, for without these effects, death would speedily leave the earth destitute of both animals and plants.

We shall first consider those functions which belong to vegetative life, and which have nutrition for their object.

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39. What is the object of the functions of relation?

40. Why are the functions of nutrition called the functions of organic life? Do the functions of nutrition exist in all organized beings?

41. Do the functions of relation belong to all living things? What is without them? When the functions of relation are suspended what is the state of the animal?

42. Why are these called functions of animal life?

43 What are vegetables?

44. What are animals?

LESSON II.

Functions of Nutrition—Nutrition of Organs—Proof of the existence of the nutritive movement—Coloring of bones—The blood is the principal agent of nutrition—use of the blood—study of this liquid—physical properties of the blood—red and white blood—Globules—Serum—coagulation—venous and arterial blood—Transformation of venous into arterial blood by the action of the air.

OF THE FUNCTIONS OF NUTRITION.

OF THE NUTRITIVE ACT.

1. Nutrition *is the vital act by which the different parts of the bodies of organized beings renew the materials of which they are composed.*

2. To effect this renovation, the animal appropriates certain substances within his reach, which are adapted to this purpose, and these substances being introduced into the body and distributed to the different organs, are there retained and become constituent parts of them.

3. At the same time that the organs thus acquire new materials, they lose others, which, having become old and useless, are in some way detached and expelled.

4. Thus, then, the new materials take the place of those which have been detached from the organ, so that its substance is, little by little, renewed.

5. When a living being thus incorporates with its organs more material than it loses, its volume augments, and of course its weight increases:—Thus, by the act of nutrition, the infant, which at birth weighed only five or six pounds, is found to have acquired, when it has reached the age of twenty-five years, more than a hundred weight, and a proportionate increase in size; but if the contrary be true, and the living being loses more material than it incorporates with its organs, it grows thin, as is often observed when the adult approaches extreme age; and when these two phenomena are in just equilibrium, its weight remains the same

6. This nutritive act takes place in all living beings.

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1. What is nutrition?

2. How do animals renew the materials of which their bodies are composed?

3. Do the organs always retain the materials acquired?

4. Why is the size of the organs not increased by the constant accession of new materials?

5 When an organ receives more material than it loses, what is the consequence? When an organ loses more than it receives what happens?

6. Does the act of nutrition take place in all things?

7. Brute bodies, as stones and minerals are not nourished. The materials of which these are composed remain the same as long as they exist, and if their volume increase it is simply by the juxta-position of substances of the same nature as their own.

8. But animals and plants on the contrary grow by *intus-susception*, that is to say, by the deposite of new particles within their very substance.

9. The continual process of composition and decomposition which constitutes the nutritive act, is not perceptible to our senses; but observations have been made which remove all doubt of its existence, even in the bones, the hardest and deepest seated parts of the body. An English surgeon, Belcher, eating of a pig which had been fed by a dyer, remarked that the bones of the animal were red, and attributing this peculiarity to the colored substances which it had eaten, conceived an idea that analogous means might serve to render visible the effects of the nutritive act; he made experiments which, repeated by a number of learned men, were crowned with entire success.

10. After feeding animals on madder for a certain time, it is always found that the bones are stained red by a deposite of this coloring matter in their substance; and after having thus fed an animal, and then suspending the use of the madder, it is found, after a certain period, that the red matter which must have been deposited in the substance of these organs, is no longer there, but has been, as we must conclude, ejected. Now, these facts may be explained by the continuous process of composition and decomposition, to which is given the name of nutrition.

11. This renovation of the constitutent materials of the body is indispensable to the continuance of life: when it stops in an organ, that organ decays, and when it ceases throughout, death soon follows.

12. The nutrition of organised bodies is effected by the aid of a liquid which conveys into all the organs, the necessary materials for their sustenance, and which serves at the same time, to carry away from their substance those particles which are detached by the nutritive act, and destined to be expelled from the body. In plants, this liquid is the sap, and in animals it is the blood.

7. Are stones nourished? How do they increase in size?

8. How do animals and plants grow in size?

9. Is the nutritive act perceptible to ourselves?

10. How was it proved?

11. What is the consequence if nutrition ceases in an organ? If in all the organs?

12. How is the nutrition of organized bodies effected? What are the names of this liquid?

OF THE BLOOD.

13. *The Blood is the nutritive liquid of animals.*

14. It is this liquid which maintains life in the organs, and furnishes them with the materials of which they are composed.

15. The blood is the source of all the humors formed in the body; as the saliva, tears, bile, &c.

16. In man, and all animals resembling him in organization, the blood is red. In a great number of others, it is colourless, or of a slight yellow or lilach tint.

17. The animals which have *red blood*, are the mammalia, birds, reptiles, fishes, and certain worms called "Annelides."

18. The animals with *white blood*, are the insects, the Arachnides. (that is spiders, and other animals resembling them,) the Crustacea, (a class of animals composed of crabs, lobsters, &c.) the mollusca, (or animals resembling snails and oysters) and some others.

19. It is a vulgar error to suppose that flies have red blood in the head: when one of these animals is crushed we see, it is true, an effusion of reddish liquid, but this is not blood, and comes from the eyes of these little beings, whose blood, like that of all insects, is white.

20 Blood is more or less thick and opaque. When examined by a microscope we perceive that it is formed of two distinct parts, namely :—

1st. Of a yellowish, transparent liquid, called *Serum*.

2nd Of a great number of solid particles of extremely small size which swim in the serum, and which are called the *globules of the blood*.

21. To these globules the blood is indebted for its red color. They are flattened and have a considerable resemblance to small pieces of money slightly drilled out in the middle (*page* 30. *fig.* 2.) Their form and size vary in different animals.

13. What is blood?
14. What is the use of the blood?
15. What is the blood the source of?
16. What is the color of the blood?
17. What animals have red blood?
18. What animals have white blood?
19. Have flies red blood?
20. Is the blood transparent? Of how many parts is it composed? What are these parts called? What is serum? What are the globules of the blood?
21. Upon what does the red color of the blood depend? What is the form of the globules? Are the size and form of the globules the same in all animals?

Fig. 2.*

22. In man, the dog, the horse, and all other animals of the class of mammalia, the globules of the blood are circular, (*a. b.*)

23. In birds, reptiles, and fishes, the globules are of an oval form, (*c.*)

24. They are smallest in the mammalia, and largest in reptiles and fishes.

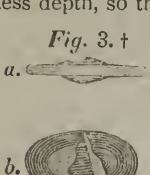
25. The blood of the mammalia and birds contains the greatest number of globules.

26. In animals with white blood, the globules are colourless, generally circular, and very few in number.

[When these globules are carefully examined, with a powerful microscope, it is seen that each one is composed of two distinct parts, and that they consist of a sort of bladder or membranous sack, in the middle of which there is found a spheroidal corpuscule,—(a diminutive body.)

[Under ordinary circumstances, this bladder is flattened, and forms, around a central nucleus, a circular border, of greater or less depth, so that, as a whole, it presents the appearance of a disk, (*a.*) swelled or bulged in the middle. The external envelope of the globules consists of a sort of jelly, which is of a more or less beautiful red colour, and is easily divided: it is to the presence of these vesicles, (little bladders,) that the blood owes its colour. The central nucleus of the globules is more consistant, and is not coloured.]

Fig. 3.†



27. In its ordinary state, the blood is always fluid, and the globules swim freely in the serum; but when drawn from the vessels which contain it, and left to itself, it is not slow to congeal, and to present the phenomenon of *coagulation.*

* *Fig.* 2.—*a*, blood of a man,—*b*, blood of a sheep,—*c*, blood of a sparrow. These globules are magnified one thousand times in diameter.

† *Fig.* 3.—*a*, globule of the blood of a frog, magnified about seven hundred times, and seen in profile: *b*, the same globule seen in front; the envelope is torn so as to show the central nucleus.

22. What is the form of the globules in the mammalia?

23. In what class of animals are the globules oval?

24. In what animals are they smallest? In what animals largest?

25. What animals have the greatest proportion of globules in the blood?

26. What is the form and colour of the globules in white blooded animals?

27. What is the ordinary state of the blood? When drawn from the vessels, and left to itself, what takes place?

28. When blood coagulates, the globules unite themselves together in a mass, and little by little separate from the serum, to form a clot more or less solid.

[Chemistry teaches us, that in man, 100 parts of blood, contain about 66 parts of water, from 6 to 7 hundredths of *albumen*, (1), from 14 to 15 hundredths of *fibrin*, (2), and colouring matter, some thousandths of fatty matters, of several salts, and traces of the peroxide of iron. Under ordinary circumstances, we cannot discover in the blood, those substances which are found in the different humors, formed at its expense; but if we arrest the action of those organs that are charged with secreting these humors, we then find in the blood, the matters in question. We must therefore conclude that they always exist in it, but in quantities too small to be appreciated by our methods of analysis; and that the organs just alluded to, do not form them, but separate them from the blood in proportion as they are presented.]

29. The blood contains all the materials necessary to the reparation and growth of the organs; consequently, it furnishes to all parts the matter, of which they are in need for their nourishment, and also imparts the excitement necessary to the maintenance of life.

30. To appreciate fully the importance of the office filled by the blood in the bodies of living animals, it is only necessary to bleed one, and observe the effects of the operation.

31. When the flow of blood continues for a long time, the animal falls into syncope, (fainting,) and if the bleeding be not arrested, all motion ceases in a few moments; respiration is stopped, and life is no longer manifest by external sign. If the animal be left in this condition, reality soon takes the place of appearance, and death speedily follows. But if we inject into his veins, blood similar to that which he has lost, we see with astonishment this semblance of a corpse return to life; in proportion as ad-

(1.) *Albumen*, is a kind of matter that enters into the composition of most of the organic tissues of animals, and almost by itself constitutes the white of eggs. It can be dissolved in water, but by the action of heat, it solidifies and becomes insoluble.

(2.) *Fibrin*, is the basis of muscular flesh. It can be separated from blood by beating it with rods before it coagulates; the fibrin adheres to the rods in the form of very elastic whitish filaments.

28. When blood coagulates what takes place?

29. What does the blood contain? What other use has the blood besides that of nourishing the organs?

30. How can you show the importance of the blood to living animals?

31. How is an animal effected by bleeding? What is the effect of injecting blood into the veins of an animal that has been exhausted by bleeding?

ditional quantities of blood are introduced into the vessels, he revives more and more, and soon breathes freely, moves with facility, resumes his habitual gait and is completely re-established.

32. This operation, known under the name of transfusion, is certainly one of the most remarkable that has been performed, and proves, better than all we could say, the importance of the action of the globules of the blood upon the living organs; for if we make use of serum, that is, blood deprived of its globules, in the same manner, we produce no more effect than if we had used pure water, and death is not a less inevitable consequence of the hæmorrhage.

33. The influence of the blood upon the nutrition of the organs may be demonstrated with equal facility.

34. When by mechanical means we diminish, in an appreciable and permanent degree, the quantity of this fluid received by an organ, we perceive that it dwindles in size, and often even decays and becomes reduced to almost nothing.

35. On the other hand we observe, that the more any one part of the body is exercised, the greater the quantity of blood it receives, and the more it augments in volume. Indeed, every one knows that muscular exercise tends most to the developement of those parts which are the seat of it; that in dancers for example, the muscles of the legs, the calf in particular, acquire an extraordinary size, while with bakers and other men who perform hard labor with their arms, the superior members or extremities become more fleshy than any other parts. Now, the muscles receive more blood when in action than when in repose, and by this afflux of blood, the nutritive act of which they are the seat, is stimulated and their volume is increased.

36. The blood in giving nourishment to the organs, and in exciting the vital movement, undergoes a change; it is impoverished not only by the deposite of the particles which the organs appropriate to themselves, and incorporate with their substance, but also by receiving the old materials which are separated from the tissue of these same organs, and which, having become useless, or even injurious, have to be expelled from the body.

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32. What is the operation of injecting blood into the veins called? What does transfusion prove?

33. Does the blood influence the nutrition of the organs?

34 What is the effect of diminishing the quantity of blood received by an organ?

35. What effect does exercise produce on the different parts of the body? Why is the volume of the muscles increased when they are much exercised?

36. Does the blood undergo any change in nourishing the organs?

37. Consequently, there is a very great difference between the blood going to the organs, and that which has already passed through them, and which has contributed to their nourishment.

38. To the first is given the name of *arterial blood*, and to the second, the name of *venous blood.*

39. Arterial blood is of a vermilion red; it coagulates very easily and contains a large proportion of globules; and finally, it is essentially necessary to the maintenance of life.

40. Venous blood is of a blackish red color; it is less coagulable and less rich than the arterial blood, but what distinguishes it above every other quality, is, that after having passed through them, it is no longer capable of exciting the vital movement in the organs.

41. Notwithstanding, the blood thus vitiated does not cease to be useful, because it easily regains its vivifying qualities.

42. By action of the air, the venous blood is changed into arterial blood; it regains its vermilion color, and becomes again fit for the maintenance of life.

43. It is this transformation of venous blood into arterial blood, which constitutes the phenomenon of respiration.

LESSON III.

Functions of Nutrition—Circulation of the Blood—the Heart—Arteries—Veins—Motion of the blood in the bodies of the Mammiferæ—Mechanism of the circulation—Phenomenon of the pulse—Venous absorption—Secretion.

CIRCULATION OF THE BLOOD.

1. The blood does not remain at rest in the body; it is constantly passing through the organs which it nourishes, and returning to the respiratory apparatus to come in contact with the air, to be again distributed to the organs.

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37. Is the blood when it comes from an organ in the same condition as when it entered?

38. What is the blood called that goes to the organs? What is it called when it has left the organs?

39. What are the properties of arterial blood?

40. What are the properties of the venous blood? What is the essential quality that distinguishes venous from arterial blood?

41. Why does blood thus vitiated cease to be useful?

42. How is venous blood changed into arterial?

43. What does this transformation of venous into arterial blood constitute?

1. Is the blood at rest in the body?

2. *The continuous passage of the blood from the respiratory apparatus towards all the organs of the body, and the return of the blood from these organs to the apparatus of respiration, constitutes the phenomenon of the circulation.*

3. This liquid, as we have seen, moves continually in a sort of circle; after having traversed all the parts which it is destined to nourish, it returns to a particular organ to come in contact with the air, then goes back to the parts whence it came, passes through them, returns again to the apparatus of respiration, and so continues as long as life endures.

4. The Apparatus of the Circulation, that is to say, the assemblage of organs destined to effect this conveyance or transportation of the blood, is composed:

First. *Of canals, or pipes, in which the blood runs.*

Second. *Of the heart which serves to set it in motion.*

5. The *heart* is the centre of the apparatus of the circulation; it is a sort of fleshy pouch communicating with the blood vessels, which receiving the blood into its interior, and which, by contracting on itself from time to time, forces this fluid into the canals, and thus keeps up a continual current in them.

6. Almost all animals have a heart. This organ exists not only in the mammalia, birds, reptiles, and fishes, but also in snails, oysters, and other animals of the class of mollusca; in crabs and lobsters; in spiders, &c.

7. The blood vessels are of two kinds, namely:

8. 1st. The *arteries* which carry the blood from the heart to all parts of the body.

9. 2nd. The *veins* which bring back this liquid from all parts of the body to the heart.

10. The arteries spring from the heart and divide into branches which *decrease in size*, and *increase in number* as they advance, and are distributed to the very numerous parts, distant from the heart.

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2. What constitutes the phenomenon of the circulation?

3. After having traversed all the parts it is destined to nourish, what becomes of the blood?

4. What is meant by the apparatus of the circulation? Of what parts is it composed?

5. What is a heart?

6. Have all animals a heart?

7. How many kinds of blood vessels are there?

8. What is the function of the arteries?

9. What is the function of the veins?

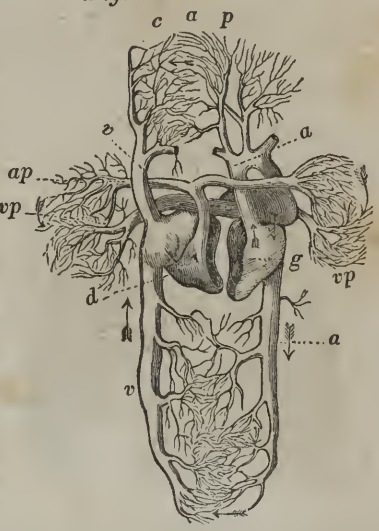
10. Where do the arteries take their rise? How are they distributed?

11. The veins present a similar disposition, but which is designed to produce an entirely opposite result, because the blood in these vessels, pursues an inverse course. They are very numerous at a distance from the heart, but, little by little, they unite to form larger canals which, in turn, again unite, so that they terminate at the heart, in only one or two large trunks.

12. The ultimate ramifications of the arteries in the substance of the organs, are continued into the radicles of the veins, so as to form a series of uninterrupted and narrow canals through which the blood passes through the organs.

13. To these delicate canals, which establish the communication between the termination of the arteries and the beginning of the veins, is applied to the name of *capillary* vessels, (*Fig.* 4.)* This name has been given to them in consideration of their extreme fineness, which makes them comparable to hairs.

Fig. 4.



* *Explanation of Fig.* 4.—This figure does not represent the natural arrangement of the heart and blood vessels; it is an ideal diagram, designed to convey some notion of the way in which the blood, in completing the entire route of the circulation, passes twice through the heart, and also passes through the two systems of capillary vessels, namely, those of the lungs in getting from the pulmonary artery into the pulmonary veins, and those of all the organs, in passing from the minute terminating branches or the aorta, into the radicals of the veins which end in the venæ cavæ. The two halves of the heart, which in reality, are only separated by a partition, are here completely isolated,—*g*, left side of the heart,—*a*, the aorta,—*c*, *a*, *p*, capillary vessels, which terminate the arteries, all of which spring from the aorta,—*v*, general venous system,—*d*, right side of the heart,—*a*, *p*, pulmonary artery,—*v*, *p*, pulmonary vein. The arrows point in the direction of the current.

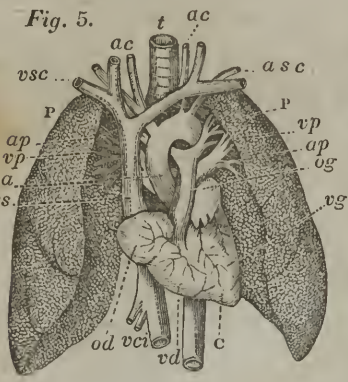
11. How are the veins arranged?
12. How do the ultimate ramification of the arteries terminate?
13. What are the capillary vessels? Why are they so called?

14. At the extremity opposite to that where we find the capillary vessels, the arteries and veins also communicate with each other, by the intervention of the cavities of the heart.

15. The result of this arrangement is, that the vascular apparatus forms a complete circle in which the blood moves, constantly returning to its point of departure.

16. The circulating circle may be compared to a tree, the trunk of which is doubled upon itself, so as to cause the ultimate ramifications of the branches to meet the ultimate divisions of the roots; the upper portion of the trunk and roots would represent the veins.

Fig. 5.



17. In all those animals which most resemble man, (anatomically,) such as the monkey, the dog, horse, ox, &c., the *heart* is placed between the two lungs, in the cavity of the chest, which anatomists call the thorax, (*Fig.* 5.)

18. The general form of the heart is that of an inverted cone, the apex down, and a little to the left. The size of the heart is very nearly that of the fist of the individual to whom it belongs.*

* *Explanation of Fig.* 5.—The lungs of a man with the heart and great vessels which arise from it,—P,P. the lungs,—*t.* the trachea which conveys air to the lungs,—c. the heart,—*od.* right auricle of the heart,—*vd.* right ventricle of the heart,—*og.* left auricle of the heart,—*vg.* left ventricle of the heart,—*vcs.* and *vci.* superior and inferior venæ cavæ, emptying into the right auricle of the heart,—*ap.* pulmonary artery going from the right ventricle to the lungs,—*vp.* pulmonary veins, passing from the lungs to the left auricle of the heart,—*aa.* the aorta,—*ac.* carotid arteries arising from the aorta, and conveying blood to the head,—*asc.* subclavian vein, coming from the arms and emptying into the superior vena cava.

14. Have the arteries and veins any other communication with each other than by the capillary vessels?

15. What is the result of the arrangement of the heart and blood vessels as described?

16. To what may we compare the circulating circle?

17. What is the situation of the heart?

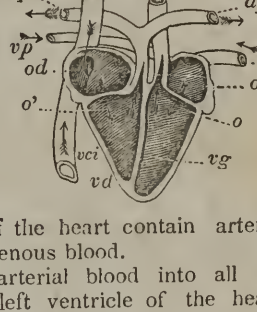
18. What is the form of the heart? What is its size?

19. This organ is enveloped in a double, membranous sac, called *pericardium*, and is suspended in the pericardium by the vessels which arise from its superior and enlarged entremity; but it does not adhere at any other point of its surface to the neighbouring parts.

20. The substance of the heart is almost entirely fleshy; it is a hollow muscle, the cavity of which communicates with the arteries and veins.

21. In man and all the mammalia, as well as birds, it has four distinct cavities. A thick, vertical partition divides it into two halves, each one forming two cavities, one above the other; a *ventricle*, and an *auricle*. (*Fig.* 6.)

Fig. 6.



22. The two ventricles occupy the inferior part of the heart, and do not communicate with each other, but each one opens into the auricle above it.

23. The cavities of the left side of the heart contain arterial blood, and those of the right side, venous blood.

24. The vessels which convey arterial blood into all the organs take their origin from the left ventricle of the heart,

Explanation of Fig. 6.—The heart opened to show the cavities in the interior of this organ.—*od*, right auricle of the heart,—*vd*, right ventricle of the heart,—*og*, left auricle of the heart,—*vg*, left ventricle of the heart,—*vcs*, and *vci*, superior and inferior venæ cavæ, emptying into the right auricle of the heart,—*ap*, pulmonary artery going from the right ventricle to the lungs,—*vp*, pulmonary veins passing from the lungs to the left auricle of the heart,—*aa*, the aorta,—*o*, left auriculo-ventricular opening,—*o'*, right auriculo-ventricular opening. The arrows point out the direction of the flow of the blood in the different vessels.

19. Has the heart any covering proper to it? How is it suspended in the pericardium? Does the heart adhere to the surrounding parts?

20. What is the substance of the heart? Is the heart solid?

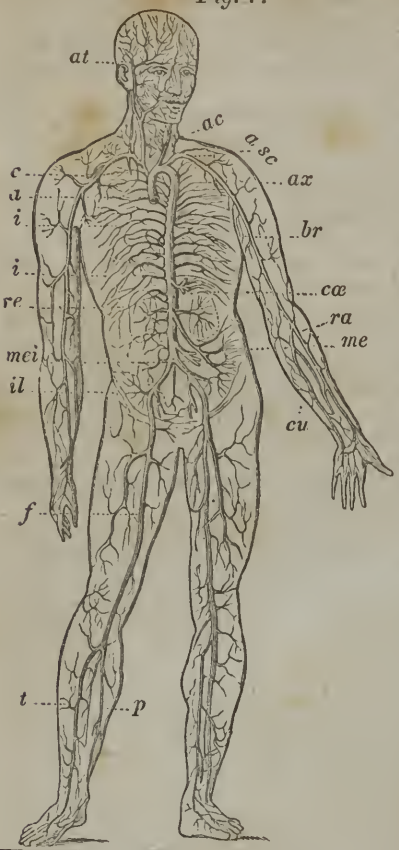
21. How many cavities has the heart? How is it divided? What are the cavities of the heart called?

22. What part of the heart is occupied by the ventricles? Do the ventricles communicate with each other? Do they communicate with the auricles? How is the auricle situated in regard to the ventricle?

23. What kind of blood is contained in the cavities of the left side of the heart? In which side of the heart is found the venous blood?

24. From what part of the heart do these vessels arise which carry arterial blood? What is the name of the great arterial trunk as it arises from the heart?

Fig. 7.



through the medium of a single trunk, called the *aorta, (Fig. 7.)**

25. This great artery first mounts upwards towards the base of the neck, then bends downwards, forming a sort of crook, passes behind the heart and descends vertically, in front of the spine, to the lower part of the belly. In its course, the aorta gives off a great number of branches, the principal of which are:

26. 1st. The two *carotid arteries* mount along the sides of the neck, and supply the head with blood; (*Fig. 7, ac.*)

27. 2d. The two arteries of the upper extremities, successively obtain the names of *subclavian*, *axillary*, and *brachial* arteries, as they pass under the clavicle, or cross the armpit, or descend along the arm to the elbow, where they divide into two branches, called the *radial* and *ulnar*, or *cubital* arteries:

Explanation of Fig. 7.—The aorta and branches which arise from it to convey the blood to all parts of the body,—*a*, the aorta,—*c*, arch of the aorta,—*ac*, carotid arteries,—*at*, temporal arteries,—*a*, *sc*, subclavian artery,—*a*2, axillary artery,—*br*, brachial artery,—*ra*, radial artery,—*cu*, cubital or ulnar artery,—*i*,*i*, intercostal arteries,—*cœ*, cœliac artery,—*re*, renal arteries,—*me*, and *mei*, superior and inferior mesenteric arteries,—*il*, iliac arteries,—*f*, femoral arteries,—*t*, tibial artery,—*p*, the peroneal artery.

25. Describe the course of the aorta?
26. What is the course and distribution of the carotid arteries?
27. What arteries supply the upper extremities?

28. 3rd. The *intercostal arteries* are several in number, and run between the ribs on each side of the body;

29. 4th. The *cœliac* artery, which is distributed to the stomach, the liver, and the spleen;

30. 5th. The *mesenteric* arteries, which ramify upon the intestines;

31. 6th. The *renal* arteries which penetrate into the kidneys;

32. And 7th. The *iliac* arteries, which in a manner terminate the *aorta*, and which convey blood to the lower extremities, descend along the thighs and are there called femoral arteries; then they divide into many branches which terminate in the feet.

33. The *veins*, which receive the blood thus transmitted to all parts of the body, follow very nearly the same course as the arteries; but they are larger, more numerous and generally situated more superficially. A great number of these vessels pass beneath the skin, others accompany the arteries, and, at last, they all unite to form two great trunks which empty into the right auricle of the heart, and which have received the names of *vena cava superior* and *vena cava inferior*. (*page* 37. *fig.* 6.)

34. The veins which come from the intestines present an important peculiarity. After uniting in a large trunk, they penetrate the liver, and there ramify like the arteries; there they again unite into a trunk and terminate in the inferior vena cava close to the heart. This arrangement of the vessels is called the *system of the vena porta*.

35. The venous blood, poured by the *venæ cavæ* into the right auricle of the heart, descends from it into the ventricle of the same side.

36. The right ventricle of the heart gives rise to a large artery, called the *pulmonary artery*, which next receives this same blood, and carries it into the lungs. (*page* 37. *fig.* 6.)

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28. What arteries run between the ribs?

29. What is the distribution of the Cœliac artery?

30. What arteries ramify upon the intestines?

31. What is the distribution of the renal arteries?

32. What arteries are distributed to the lower extremities?

33. What is the general course of the veins? In what respect do the veins differ from the arteries generally? Where do the great venous trunks empty? What are they called?

34. What is the peculiar arrangement of the veins coming from the intestines? What is it called?

35. What becomes of the venous blood after entering the right auricle of the heart?

36. What artery arises from the right ventricle? Into what part does the pulmonary artery carry the blood?

37. This vessel divides into two branches, one going to the right and the other to the left, to enter the two corresponding lungs, and are divided into almost an infinity of branches, which are spread over the surface of the little membranous cells of these organs.

38. The capillary vessels by which the pulmonary arteries terminate, give rise to veins, which unite together and finally form two large vessels, called *pulmonary veins*, which empty into the left auricle of the heart. (*page* 36, *fig.* 5.)

39. Consequently, the pulmonary veins receive the venous blood, which was brought to the lungs by the pulmonary artery, and which has now become arterial, by the effect produced on it, by contact with the air in the interior of these organs; they carry it back again to the heart and pour it into the left auricle.

40. Finally, from the left auricle this fluid descends into the left ventricle, whence we have already seen it issue to be distributed to the different parts of the body, through the medium of the aorta and its branches.

To recapitulate what has just been said, on the route pursued by the blood, in the apparatus of the circulation in mammiferous animals and birds, we see:

41. 1st. That the venous blood arrives from all parts of the body by the general system of veins;

2d. That from these veins it enters the right auricle of the heart;

3rd. That from the right auricle it passes into the right ventricle;

4th. That from the right ventricle the venous blood passes through the pulmonary artery to the lungs;

5th That in the capillary vessels, which form the termination of the pulmonary artery, and commencement of the pulmonary veins, this liquid is changed into arterial blood;

6th. That this arterial blood returns from the lungs, through the pulmonary veins, and enters the left auricle of the heart;

7th. That from the left auricle it descends into the ventricle of the same side;

8th. That from the left ventricle it is forced into the aorta, by which it is distributed to all parts of the body.

---

37. What is the distribution of the pulmonary artery?

38. What is the origin of the pulmonary veins? Where do they empty?

39. What kind of blood do the pulmonary veins convey to the heart? How is the venous, changed into arterial blood?

40. What becomes of the blood after it enters the left auricle?

41. What is the route pursued by the blood in the apparatus of the circulation?

42. And 9th.—and finally, that in the capillary terminations of the system of canals formed by the aorta, the arterial blood acts upon the organs, is changed there into *venous* blood, and enters the veins to be carried again to the heart.

43. In accomplishing the circulatory circle, the blood then passes twice through the heart, in the state of venous blood on the right side, and in the state of arterial blood in the left side of this organ ; (*page* 36. *fig.* 5. *&* *page* 42. *fig.* 8.) yet, the circulation is complete, because the pulmonary and aortic cavities of the heart do not open one into the other, and the venous blood passes through the entire respiratory apparatus to be transmuted into arterial blood.

44 The mechanism by which the blood moves through these vessels is easily understood. The cavities of the heart contract and enlarge alternately, and by contracting they force the blood into the canals with which they (the cavities) are in communication.

45. The two ventricles contract at the same time, and while their sides or parietes relax, the auricles in their turn contract.

46. The movement of contraction bears the name of *systole*, and the term *diastole* is applied to the opposite movement, or dilatation.

47. The beating or pulsation of the heart is very frequent ; in man of adult age it takes place from sixty to seventy-five times in a minute ; in old men the number of beats is a little increased, and in very young infants it is generally about one hundred and twenty. But a variety of circumstances may influence both the frequency and force of the beats of the heart; they are accelerated by exercise, by moral emotions, and by a great number of diseases; in swooning or syncope, they are considerably diminished, or even completely interrupted.

48. The left ventricle in dilating fills with blood, and in contracting afterwards, forces out the liquid which it contains.

49. This ventricle communicates only with the left auricle by an opening called the *auriculo-ventricular* opening, and with the

42. Where is the arterial changed into venous blood?

43. In accomplishing its entire circle, how many times does the blood pass through the heart?

44 What causes the blood to move in the blood vessels?

45. Do the auricles and ventricles of the heart contract at the same time?

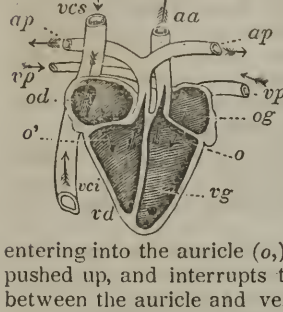
46. What is the contraction of the heart called? What is its dilation called?

47. What is the frequency of the heart's pulsation? Is it most frequent in infants or in old men? What circumstances influence the frequency o. the heart's pulsation?

48. When the left ventricle dilates, what happens?

49. With what does the left ventricle communicate?

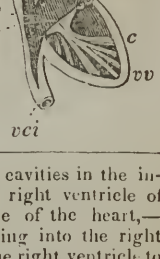
Fig. 8.



aorta, (*Fig.* 8, *aa.*); the blood, at the moment of its contraction, must then either flow back into the auricle, (*og.*) or enter the aorta.

50. Now, around the edges of this *auriculo-ventricular* opening, (*Fig.* 9, *va.*) there is a sort of valve, called the *mitral valve*, which is so arranged as to rise up, and close this opening, when it is pushed from below upwards. From this construction, it happens, that when the blood tends towards entering into the auricle (*o,*) the *mitral valve* is pushed up, and interrupts the communication between the auricle and ventricle.

Fig. 9.



51. Therefore, when the left ventricle contracts, the blood finds no other outlet than the aorta, and enters this vessel which it distends with more or less force, for its parietes, as well as those of all the arteries, are very elastic.

52. Other valves situate at the entrance of the aorta, prevent the blood from returning into

Explanation of Fig. 8.—The heart opened to show the cavities in the interior of this organ.—*od*, right auricle of the heart,—*vd*, right ventricle of the heart,—*og*, left auricle of the heart,—*vg*, left ventricle of the heart,—*vcs.* and *vci*, superior and inferior venæ cavæ, emptying into the right auricle of the heart,—*ap*, pulmonary artery going from the right ventricle to the lungs,—*vp*, pulmonary veins passing from the lungs to the left auricle of the heart,—*aa*, the aorta,—*o*, left auriculo-ventricular opening,—*o'*, right auriculo-ventricular opening. The arrows point out the direction of the flow of the blood in the different vessels.

Explanation of Fig. 9.—The right auricle of the heart opened to show the position of the valve, *va*, in the auriculo-ventricular opening, which, during the contraction of the ventricle, (*vv,*) prevents the blood from entering the auricle, (*o,*); we observe small cords passing from the edge of this valve and attaching themselves by their inferior extremities to the parietes of the ventricle, (c.) Like the rest of the heart, they are fleshy, and prevent the valve from turning entirely over into the auricle, when the blood, pressed by the ventricle, elevates it. The aorta is also open to show the valves, (*v'*) which surround its entrance, and which are differently arranged from those of the ventricle.

50. Where is the mitral valve placed? What is the use of the mitral valve?

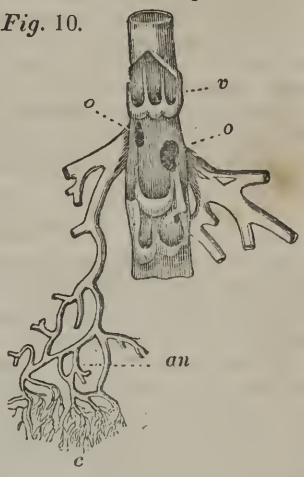
51. Into what part is the blood forced by the contraction of the left ventricle? Why does it not go back into the auricle?

52. What prevents the blood from returning into the left ventricle from the aorta? Are the arteries elastic or not?

the left ventricle, so that, pressed by the elastic force of the arterial parietes, it is continually pushed forward, from the heart towards the extremities of the arteries.

53. The phenomenon known under the name of the *pulse*, is nothing else than the motion caused by the pressure of the blood against the parietes of the arteries, every time that the heart contracts. According to the frequency and force of these motions, we may judge of the manner in which the organ beats, and draw therefrom, deductions useful in medicine. But the pulse is not felt in all parts; to perceive it, we must slightly compress an artery of a certain volume between the finger and a resisting surface, of a bone, for example, and select a vessel situated near the skin, as the radial artery at the wrist.

Fig. 10.



54. The impulsion received by the blood at its exit from the left ventricle of the heart, is communicated to the capillary vessels and to the veins, and determines the progression of the blood in them. But the return of the venous blood towards the right ventricle, is favoured by some other circumstances. In the veins of the extremities, the membrane which lines these vessels, forms a great many folds or *valves*, (*Fig.* 10, *v.*) which open when the blood pushes them from the extremities towards the heart, and shut so as to close the passage, when this liquid flows in a contrary direction. Now, this arrangement prevents the blood from flowing back towards the capillaries, and thus facilitates its passage towards the heart; for, every time a vein is pressed by the movements of the parts in its vicinity, the blood is pushed forward.

Explanation of Fig. 10.—A large vein opened to show the valves, (*v*,) which are found in these vessels,—*o*,*o*, openings of two of its branches,—*an*, anastomosis of two veins,—*c*, capillary roots of the vein.

53. What is the pulse? Is the pulse felt in all parts? What does the pulse indicate? What circumstances are to be observed in order to feel the pulse?

54. What causes the blood to circulate in the capillary vessels? What other circumstance, besides the impulsion received from the heart, favours the return of the blood towards the right ventricle?

55. The passage of the blood through the right cavities of the heart, is effected in the same manner as in the left cavities. Between the right auricle and right ventricle there also exists a valve, called the *tricusped valve*, which prevents the blood from returning from the ventricle into the auricle, (*p.* 42. *fig.* 8. & *p.* 43. *fig.* 10.) and by the contractions of this ventricle the blood is forced to circulate in the vessels of the lungs and to arrive at the left auricle.

56. It is the ventricles, as we have seen, which force the blood into the arteries and cause it to circulate.

57. The auricles are a sort of reservoirs, designed to contain the blood arriving by the veins, and to pour it into the corresponding ventricles.

58. Such is the march of the blood, not only in man and all the mammalia, but also in birds; in the sequel we shall see that in reptiles and fishes, the structure of the heart is less complicated, and that the blood follows a somewhat different direction.

OF ABSORPTION.

59. The blood, in passing through the veins from their capillary origin in the substance of the organs to their termination in the right auricle of the heart, carries with it all the fluids which in some way filter through the parietes of these vessels. Fluid substances which may be in contact with the surface of the body and of the great hollow cavities in its interior, or which are deposited in the depth of the organs, are, as it were, pumped up, more or less rapidly, and carried into the torrent of the circulation.

60. *To the passage of substances, of whatever kind, from the exterior, into the interior of the blood vessels through their parietes, or particular canals, and their mixture with the blood,* is given the name of Absorption.

61. Substances thus absorbed, generally, penetrate directly into the veins; but under some circumstances they are carried thither by particular canals, called *lymphatic vessels.* In describing the act of digestion, we shall have occasion to refer again to these vessels.

55. How is the passage of the blood through the right side of the heart effected? What valve exists between the right auricle, and right ventricle? How is the blood forced to circulate through the lungs?

56. What forces the blood into the arteries?

57. What are the auricles?

58. Is the structure of the heart, and the circulation the same in all animals?

59. Do substances different from the blood enter into the circulation?

60. What is absorption?

61. Is absorption effected by the veins only?

62. All parts of the body may be the seat of a more or less rapid absorption; it is by this phenomenon that liquids, introduced into the stomach are found, a very short time afterwards, mingled with the venous blood, and that certain vapors, mixed with the air drawn into the lungs, sometimes act upon remote parts of the body, such as the brain, as happens when we breathe alcoholic vapors. It is also by absorption alone, that we can explain how poisons applied to the lips, the eye, or to a slight erosion of the skin, penetrate into the interior of the body, and cause death, often with as much rapidity as if they had been conveyed directly into the stomach.

63. It is by the absorption, which takes place in the substance of all the organs, that the old materials no longer of use and separated from the living tissues by the nutritive act, are poured into the circulating torrent to be carried out of the body.

OF EXHALATION AND OF SECRETION.

64. The blood, in circulating through the body, is not limited to the nutrition of the organs through which it passes, and to mingling with it absorbed matters; on passing into certain parts of the body, it abandons a portion of the matters which it contains, and in this way gives birth to peculiar liquids called *humors*.

65. This separation of the contained matters from the blood may take place in two ways: by exhalation and by secretion.

66. Exhalation *is the separation of a portion of the most aqueous part of the blood, which, in some manner, filters through the parietes of the vessels.*

67. The exhaled liquids do not differ much from serum, except that they contain more water. Sometimes they accumulate in the internal cavities of the body; at others they are diffused over the surface and are evaporated into the air. It is in this way that a considerable quantity of vapor escapes from the lungs, and a very active evaporation takes place upon the surface of the skin.

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62. Does absorption take place in all parts of the body?

63. By what process are those materials which are no longer of use, carried out of the body?

64. Is the office of the blood limited to the nutrition of the organs through which it passes?

65. In how many ways may matters contained in the blood be separated from it?

66. What is exhalation?

67. What is the nature of the liquid exhaled? What becomes of the exhalations?

68. Secretion *is the production of certain liquids which resemble the serum in nothing, and which are also formed at the expense of the blood.*

69. Tears, saliva, bile, urine, &c., are liquids, secreted in this way.

70. The phenomenon of secretion always takes place in particular organs. Sometimes it is seated in the follicles, and sometimes in the glands.

71. The *follicles* are very small pouches which are strewed through substance of the membranes, and which open upon their surface, by small pores.

72. The *follicles* of the skin secrete the sweat; those on the edge of the eye-lids which secrete the yellow matter which sometimes accumulates during sleep, are organs of this kind.

73. The *glands* are more voluminous organs, composed of small granulations united in a compact and distinct mass. These granulations are the seat of secretion, and they generally communicate externally, by small tubes or conduits, which, uniting together like the roots of a tree, finally form an excretory canal by which the secreted liquid is poured out.

74. The salivary glands which secrete the saliva, the lachrymal glands, which secrete the tears, and the liver which secretes the bile, are organs of this class.

75. The act of secretion is not designed simply to produce liquids useful in the exercise of certain functions, such as the saliva and bile; but also to free the blood from the old materials, separated from the tissue of the organs by the act of nutrition, and other useless or injurious matters, which may become mixed with it by the effect of absorption. The secretion of urine, which takes place in the kidneys, (situated in the abdomen, one on each side of the spine) and the expulsion of it which follows, is the principal means by which this sort of purification of the blood is effected.

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68. What is secretion?
69. Give examples of the secretions?
70. In what part does the secretion take place?
71. What are follicles?
72. How is the sweat produced?
73. What are glands? How do they communicate externally?
74. Give examples of secreting glands?
75. What are the objects of secretion? What organs secrete the urine?

LESSON IV.

FUNCTIONS OF NUTRITION—*Respiration—Necessity of contact with the air—Asphyxia—Composition of the atmosphere—Principal phenomena of respiration—the Lungs—Mechanism of respiration—Animal Heat.*

OF RESPIRATION.

We have already seen that the arterial blood, by its action upon the living tissues, loses those qualities which make it fit for the support of animal life, and after having been in this way vitiated, it regains its first properties by contact with the air.

1. *The transformation of venous into arterial blood, by the action of the air, constitutes the phenomenon of* RESPIRATION.

2. Respiration, and consequently contact with the air, is indispensable to all living beings; plants as well as animals feel the want of it, and when deprived of it, both very soon perish.

3. When, from any cause whatever, respiration is arrested, all the animal functions are disturbed. Life soon ceases to be manifest; the animal falls into a state of *asphyxia* or apparent death, and in a very short time life becomes entirely extinct.

4. At first sight, we might believe that animals which live in the depths of the waters, as fishes, are removed from the influence of the air, and consequently form an exception to the law of which we have spoken; but it is not so, for the liquid in which they dwell, absorbs and holds in solution a certain quantity of air which may be easily separated from it, and which is sufficient for the support of life in them; it is impossible for them to exist in water deprived of its air, and they are seen to become asphyxiated, and die, just as the mammiferæ and birds do, when excluded from the action of the atmospheric air under its ordinary form.

5. In man and in the other mammalia the apparatus of respiration consists:

1st. Of the lungs, organs which are the seat of this function;

2nd. Of canals, by which the air from without is conveyed into the lungs;

3rd. Of organs which effect the entrance of the air into this apparatus, and which afterwards expel it, to make room for fresh supplies of this fluid.

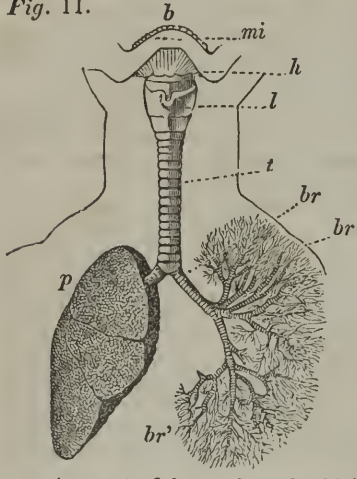
1. What constitutes the phenomenon of respiration?
2. Is contact with the air necessary to all living beings?
3. If respiration be arrested what is the consequence?
4. Do fish require contact with the air?
5. What parts compose the apparatus of respiration?

6. The *lungs*, (*Figure* 11.) are very elastic, spongy organs, contained in the cavity of the chest, and formed by the union of a great number of membranous vesicles resembling little cells, which generally communicate one with another. Into these vesicles is introduced the external air: when it penetrates their cavities, it distends them and thus augments the entire volume of the lung, which happens in *inspiration;* on the contrary, when the lungs are emptied of the air which distends them, their volume diminishes, as happens in *expiration.*

7. The lungs communicate with the external air by a long canal which is terminated by the mouth and nose.

8. The air to reach these organs, passes through the nasal fossæ, or nostrils, or through the mouth into the *pharynx*, then enters into the *larynx*, descends along the *trachea*, or windpipe, and is distributed to the pulmonary cells by other canals or tubes, called bronchiæ, (*Fig.* 11.)

Fig. 11.



9. The nasal fossæ, and the mouth terminate internally in the *pharynx*, or gullet, so that the supply of air necessary for respiration may reach this cavity by either route.

10. At the bottom of the pharynx, or swallow, we find an opening called the *glottis*, which leads into the *larynx*, and permits the air to enter therein.

11. The *larynx* is a short tube of considerable diameter, situated at the superior and anterior part of the neck, and which contributes to the production of the voice.

Explanation of Fig. 11.—The lungs and trachea; on the left side of the cut, the lung is represented entire (*p*,) and on the right, are the canals which convey air into the interior of all the cells of this organ,—*b*, the mouth,—*mi*, the lower jaw,—*h*, the hyoid bone,—*l*, the larynx,—*t*, the trachea, or windpipe,—*br*. bronchiæ,—*br'*, ramuscles or small branches of the bronchiæ,—*p*, the lungs.

6. What are the lungs?
7. How do the lungs communicate with the external air?
8. How does the air reach the lungs?
9. How do the nostrils terminate internally?
10. To what part does the glottis lead?
11. What is the larynx?

12. The *larynx* is prolonged inferiorly into a long tube, called the *trachea* or wind pipe, which descends through the neck, and enters into the thorax. This tube is formed by a series of cartilaginous rings, and is lined internally by a thin membrane, which also lines the larynx, and is continuous with that of the pharynx. The cartilaginous rings of the trachea are very elastic, and prevent this air canal from being effaced, that is, from having its sides pressed together, and thus offer an obstacle to the passage of the air.

13. At its lower extremity, the trachea is divided into two branches, one going to each of the two lungs; they are called *bronchiæ*.

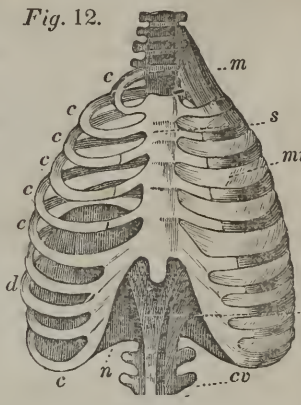
14. Soon after they enter the lungs, these bronchiæ are subdivided, and ramify in an almost infinity of branches, so as to furnish every pulmonary cell with a little branch, which opens into it, and conveys there, the air necessary to respiration.

15. The instrument which causes the air to pass through these tubes, and to enter the lungs, or to go out from them is the *thorax*, (*Fig.* 12.)

16. The mechanism by which this phenomenon is produced is very simple, and in almost every respect resembles the play of a pair of bellows, except that the air escapes by the same passage that it entered the lungs, which is not the case in the bellows.

17. The lungs are lodged in a great cavity called the chest, or *thorax*, the sides of which are moveable, and so arranged, as to

Fig. 12.

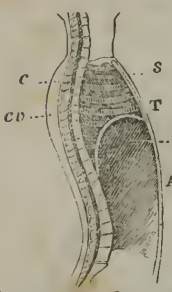


Explanation of Fig. 12.—The thorax. On the right side of the cut are seen the muscles which fill the spaces between the ribs; on the left side, they have been removed,—*cv*. the vertebral column, the greater part of which is concealed by the sternum, (*s*),—*c,c,c,c*, ribs of the right side,—*mi*, intercostal muscles,—*s*, the sternum,—*d*, the diaphragm; a part of which is seen below the thorax, and between the ribs on the right side, but it is concealed on the left by the ribs and intercostal muscles.

12. What is the trachea? What is its structure?
13. What are the bronchiæ?
14. How do the branchiæ terminate?
15. What causes the air to pass through the lungs?
16. To what is this mechanism comparable?
17. Where are the lungs situated? What happens when the thorax dilates? How does the air escape from the lungs?

enlarge and diminish the size of the cavity alternately; the lungs follow these motions and dilate, and contract in consequence; now, in the first case, (when the thorax dilates,) the air, pressed by all the weight of the surrounding atmosphere, is forced into the chest, through the mouth or nostrils, and trachea, and fills the pulmonary cells, in the same way that water mounts in the body of a pump when the piston is raised. In the second case, (in the act of expiration), the air contained in the lungs, is on the contrary, compressed, and partially escapes by the route which served it for entrance.

Fig. 13.



18. The cavity of the *thorax*, (*Fig.* 13. T.) is formed principally by the ribs, which are attached, posteriorly, to the spine or vertebral column, and in front to the bone of the *sternum;* the spaces which exist between the ribs, are filled up by muscles, and below, this species of chamber is separated from the belly by a fleshy partition called the *diaphragm.*

19. Inspiration, or the enlargement of the chest, is produced in two ways; 1st. by the elevation of the ribs; 2nd. by the muscular contraction of the *diaphragm*, which, in a state of repose, rises into the chest in the form of an arch, and which in contracting, is lowered down. Expiration, or contraction of the chest, on the contrary, is produced by the depression of the ribs, and relaxation of the diaphragm. We observe many degrees in the extent of these movements; and in ordinary respiration, the quantity of air received into, or expelled from the lungs, does not much exceed one seventh part of what these organs are capable of containing. The number of respiratory movements varies in different individuals according to the age; in adult age, we count about twenty inspirations a minute, in infancy they are much more frequent.

20. We have seen that it is by the nose or mouth, the pharynx, the larynx, the trachea, and the bronchiæ, that the air enters into

Explanation of Fig. 13.—A vertical section of the trunk, to show the position of the diaphragm (*d.*) which separates the abdomen (A.) from the thorax (T.) into which it rises up like an arch,—*cv*, vertebral column,—*c*, ribs, —*s*, sternum.

18. How is the cavity of the thorax formed? What separates it from the belly?

19. How is inspiration produced? How is inspiration effected? How many inspirations does an adult take in a minute?

20. How does the air act upon the blood?

the lungs The venous blood, which is to be subjected to the salutary influence of this air, arrives, at the same time, in the little vessels, which ramify in every direction over the sides of the cells; consequently, it is through the very sides of these capillary vessels that the air acts upon this fluid.

21. The blood coming to the lungs is of a blackish red color, and is not fit to support life in the organs; but so soon as it comes in contact with the air it changes its nature; its color becomes of a bright red, regains its vivifying properties and acquires all the characteristics of arterial blood.

22. The atmospheric air which thus enters into the lungs, and there produces so remarkable a phenomenon, is chiefly composed of two substances which differ very much from each other; namely *oxygen*, and *azote* or *nitrogen*.

23. Though the oxygen which enters into the composition of the air forms but about one fifth (21 parts in the 100,) it is its most important part. It is to the oxygen that the air owes its property of supporting life, and of sustaining the burning of combustible bodies when inflamed.

24. *Azote, or Nitrogen,* which enters into the composition of the air in the proportion of 79 parts in a 100, is unfit for respiration, and incapable of supporting combustion. It seems to serve only to dilute the oxygen, and thus mitigate the otherwise too irritating action of this gas.

25. By being breathed the air changes its nature; its oxygen disappears little by little, and is replaced by another fluid called *carbonic acid gas*.

26. This *carbonic acid gas* is composed of oxygen combined with *carbon*, derived from the blood; instead of being fit to support life, it acts as a poison on animals that breathe it for a short time, and causes death.

27. On this account, by the respiration of animals, the air is gradually vitiated, and, if it were not renewed, would soon occasion asphyxia.

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21. What is the color of the blood when it enters the lungs? What change does contact with the air produce upon it?

22. Of what is atmospheric air composed?

23. What is the proportion of oxygen in the air? What is the great use of the oxygen?

24. What is the proportion of nitrogen in the air? Is it capable of supporting animal life? What seems to be its use?

25. What effect is produced upon the air by breathing it?

26. Of what is carbonic acid gas composed? Whence is the carbon derived? How does it act on those animals that breathe it?

27 What would happen if the air breathed by animals were not renewed?

28. [Carbonic acid gas, which extinguishes bodies in combustion in the same way as azote, is formed by the combustion of charcoal; also, during the fermentation of wine, and of beer, which makes it sparkling and frothy.

29. It is upon the action of this gas on the animal economy that the asphyxia, produced by the vapor of charcoal, depends, as well as the greater number of accidents of the same sort which occur in mines, caves, wells, and vats wherein wine or beer is fermenting. In a grotto near Naples, this gas is continuously disengaged from the earth, and gives rise to phenomena, which, at first sight, appear very singular, and excite the admiration of the traveller; when a man enters this cavern he experiences no inconvenience in his respiration; but a dog following him very soon falls down in a state of asphyxia at his feet, and would soon expire, were he not speedily removed to the pure air. This arises from the fact that the carbonic acid gas being much heavier than the air, sinks down and forms upon the bottom of the cave a bed or stratum of about two feet thick. Now, a dog that enters the grotto is necessarily plunged over his head into this mephitic gas, and must necessarily become asphyxiate, while a man who is very much taller, only has the lower part of his body exposed to the action of the carbonic acid, and breathes freely the air which floats above. This remarable place is known under the name of the *Grotto del Cano, or dog's grotto.*]

30. The air which escapes from the lungs is composed of the nitrogen inspired, of a portion of oxygen not employed, and of carbonic acid furnished by the act of respiration.

31. The expired air is also loaded with vapor of water exhaled from the blood during its passage through the capillary vessels of the lungs. This vapor becomes very perceptible, when the cold condenses it, at the moment of its issue from the body, and constitutes what physiologists call *pulmonary transpiration.*

32. Since the air is quickly vitiated by respiration, and its oxygen disappears to be replaced by the carbonic acid, we readily infer, that this fluid must be constantly renewed in the lungs, and in fact that this takes place in consequence of the alternate movements of inspiration and expiration.

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28. How is carbonic acid gas formed?

29. Upon what do certain accidents in mines, caves, wells, &c. depend? What is the *Grotto del Cano* near Naples remarkable for?

30 Of what is the air which escapes from the lungs composed?

31. What is pulmonary transpiration?

32. Why is it necessary te renew the air in the lungs?

33. We are informed of the degree of alteration which the air has undergone in our lungs, by the sensation which induces us to renew it. This sensation, scarcely appreciable in ordinary respiration, because we hasten to comply with the necessity of frequently renewing the air, becomes painful if not promptly satisfied; and is sometimes accompanied by anxiety, and even agony; an instructive warning of the imperious necessity of respiration.

34. In man there is commonly twenty inspirations per minute.

35. In all the mammalia, in birds, and in reptiles, respiration takes place in lungs, and very nearly in the same manner as in man.

36. In the greater number of aquatic animals, such as fishes, lobsters, oysters, &c., it is altogether different, and respiration takes place through the medium of a sort of membraneous fringes called *branchiæ;* we shall recur to this in the sequel.

37. The air necessary to the support of life in insects, penetrates into all parts of their bodies through particular canals called *tracheæ.*

38. Finally; there are some animals which have neither *lungs* nor *branchiæ*, nor *tracheæ*, in which respiration is accomplished by the surface of the skin. The earth-worm is an example of this kind.

OF ANIMAL HEAT.

39. The greater number of animals appear cold when we touch them, and indeed, the temperature of their bodies is not much above that of the atmosphere, and changes with it. In man, and other animals that approach him in their organization, it is otherwise; they have the faculty of producing a sufficient quantity of caloric to maintain their temperatures, nearly always at the same degree, under all atmospheric changes, and keep themselves warm.

40. We designate under the name of *cold blooded animals*, all those whose proper heat is not very perceivable, and call those *warm blooded animals* which produce sufficient heat independently of the atmosphere surrounding them.

33. How are we made acquainted with the alteration the air has undergone in the lungs?

34. How many times does a man respire in a minute?

35. Does respiration take place in lungs in all animals?

36. In what organs does respiration take place in aquatic animals?

37. How does air enter the bodies of insects?

38. How does respiration take place in those animals which have neither lungs, nor branchiæ, nor tracheæ?

39. Are all animals of the same temperature?

40. What is meant by cold blooded animals? What is meant by warm blooded animals?

41. The production of this heat, which is called *animal heat*, seems to depend upon the act of respiration.

42. The combination of the oxygen of the air with the venous blood, in the interior of the lungs, as we have already seen, causes the formation of a certain quantity of carbonic acid gas, in the same manner as in the case where oxygen combines with carbon, in producing the phenomenon of combustion, and, in both instances, must extricate a greater or less quantity of heat.

43. The faculty of thus producing heat, is common to all animals; but the greater part of them develope it in so small a degree that it is not apprcciable by our ordinary thermometers, while in others, it is so great that we do not require physical instruments to ascertain its existence.

44. The only warm blooded animals are the mammalia and birds; all the rest are cold blooded.

45. The temperature of the body of man, is about 101 degrees of Fahrenheit. It is about the same in the other mammalia, but birds produce more heat, their temperature rising to about 108° Fahrenheit.

LESSON V.

FUNCTIONS OF NUTRITION—*Digestion—Mouth—The prehension of aliments—Mastication—Teeth—Their structure—The manner of their formation—Their form and use—Saliva—Salivary glands—Deglutition—Pharynx—Œsophagus.*

1. The blood, as we have seen, in nourishing all the organs, it may be said, loses somewhat of its properties, and requires to retrieve the losses which it thus undergoes; now, it is renewed by receiving new materials from the productions of the earth.

2. These materials, destined to the support of the blood, and consequently to the support of the whole body, are furnished by the various *aliments* or food.

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41. Upon what does the production of animal heat depend?
42. How is animal heat produced?
43. Is the faculty of producing heat common to all animals?
44. What animals are warm blooded?
45. What is the temperature of the body of man? What is the temperature of birds?

1. How does the blood regain those properties which it loses by nourishing the organs?
2. What furnishes the materials for the support of the blood?

3. That they may be nourished, all living beings require that alimentary substance should be introduced into their bodies from time to time.

4. Plants pump up by their roots the aliments furnished them by the earth, and these matters are mingled with the nutritious liquid called *sap*, which permeates throughout their tissues without having undergone any preparation.

5. With animals it is altogether different. The aliments, previously to being absorbed and diffused through the different parts of the body, to afford nourishment to the organs, and to enter into the composition of their tissues, have to undergo a certain process of preparation, called *digestion*.

6. Digestion has for its object:

1st. To separate from alimentary substances the nutritive part from that which is not.

2nd. To transform this nutritive part into a peculiar liquid, fit to mix with the blood and nourish the organs, which liquid is called *chyle*.

7. The process of digestion always takes place in a cavity situated in the interior of the body and communicating externally in such a way that aliments may enter it.

8. All animals are provided with a *digestive cavity*.

9. Plants, on the contrary, having no need to digest aliments, have no such cavity. [The alimentary surface of a plant is the exterior of its root spread out in the earth.]

10. In some animals the digestive cavity is simply a pouch, communicating externally by a single opening, which performs the functions both of a mouth and of an anus.

11. But with the greatest number it is otherwise. The digestive cavity has the form of a tube, open at its two ends and enlarged about the middle. This enlarged portion of the digestive tube is named *stomach*, and serves to contain the aliments, while the greatest part of the process of digestion is performed.

3. That living beings may be nourished, what circumstance is necessary?

4. Do the nutritious fluids, received by plants from the earth, undergo any process of preparation or digestion?

5. In order to nourish animal organs, is it sufficient to introduce food into the stomach?

6. What is the object of digestion? What is chyle?

7. Where does digestion take place?

8. Have all animals a digestive cavity?

9. Why have plants no digestive cavity?

10. What is the nature of the digestive cavity in some animals?

11. What is the form of the digestive cavity in the greatest number of animals? What part is called the stomach?

12. The superior opening of this tube is the *mouth;* it is through it that food enters the digestive cavity. The inferior opening, called *anus*, is destined as an outlet to matters unfit for nutrition, which are separated from the food by digestion.

13. In quadrupeds and most other animals, we distinguish, in this alimentary tube, diverse portions, the uses of which are different; they are:

1st. The mouth.
2nd. The pharynx or swallow
3rd. The Œsophagus.
4th. The Stomach.
5th. The Intestine.

14. Other organs, or instruments, also concur to effect the digestion of food, and constitute, with the tube of which we have just spoken, the digestive apparatus; the principal are:

1st. The teeth destined to divide and grind the food.

2nd. Certain glands, such as the liver and salivary glands, serve to form the humors, which act upon the food in order to determine its digestion.

3rd. Of particular vessels destined to pump into the intestine the nutritious juices, produced by digestion, and to mix them with the blood.

In short we might consider as being in some sort auxiliary to the digestive apparatus, certain organs with which certain animals seize their food and introduce it into the mouth; but these instruments principally serve other purposes and do not really belong to the apparatus of digestion.

15. The process of digestion is very complicated, and is made up of several phenomena or distinct acts, which take place in different parts of the digestive apparatus, and which have, for instruments, particular organs.

16. These phenomena are:

1st. The prehension of aliments.
2nd. Mastication.
3rd. Insalivation.
4th. Deglutition.
5th. Chymification, or stomach-digestion.
6th. Chylification, or intestinal digestion.
7th. Absorption of chyle.

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12. What are the terminations of the digestive tube?

13. What are the different portions of the alimentary canal?

14. What other organs belong to the digestive apparatus? What is the use of the teeth?

15. Is the process of digestion confined to the stomach exclusively?

16. What are the several acts or phenomena which constitute digestion?

8th. The expulsion of the residue, left by the aliments after digestion is finished.

We will now study successively these different phenomena, and the organs which produce them.

OF THE PREHENSION OF ALIMENTS.

17. The first phenomenon of the process of digestion is the prehension of aliments, that is, the act of seizing them and introducing them into the mouth.

18. The *mouth* is a cavity of an oval form, closed in front by the lips, on the sides by the cheeks and jaws, above by the palate, and below by the tongue; behind it is continuous with the pharynx or swallow, but is separated from it by a kind of curtain called the *velum palati*—(veil of the palate,) and which may be elevated or depressed so as to close the passage or leave it free. (*page* 63 *fig.* 21.)

19. The entrance to the mouth may be closed or opened by movements of the jaws and lips. On the prehension of aliment, the latter are separated to permit the entrance of the substance, and are immediately afterwards closed to prevent its escape.

20. With most animals the prehension of aliments is performed by the lips and jaws alone; but with some, other organs are employed to seize the substances and convey them to the mouth. With man and monkeys, the hand thus becomes the chief instrument of the prehension of aliments; with the elephant it is his trunk, and with parrots the claw.

21. With most animals the food remains for some time in the mouth, to be chewed and mixed with saliva.

OF MASTICATION.

22. Liquid aliments may be immediately swallowed; but solid food to be swallowed and digested with facility should be previously divided into very small morsels.

23 This division, called *mastication*, is effected by the aid of the teeth, which, set in motion by the jaws, press upon the food and cut or crush it.

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17. What is the prehension of aliments?

18. What is the mouth? What separates the mouth from the pharynx?

19. Is the entrance of the mouth provided with the means of being closed or opened?

20. How is the prehension of food effected?

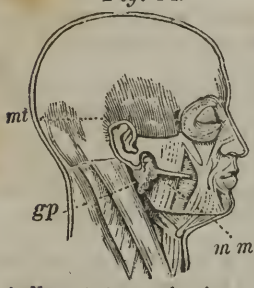
21. Does the food pass at once from the mouth to the stomach?

22. May all kinds of aliment be immediately swallowed?

23. What is mastication? How is it effected?

24. In man, and those animals which, in their organization, resemble us most, the two jaws are situated one above the other; the upper jaw is fixed immovably to the cranium; but the lower jaw is only attached to it, at its posterior part, and is there held on each side by a sort of hinge or joint, which permits it to be separated from and approached to the upper jaw.

Fig. 14.



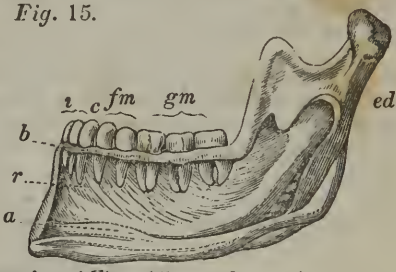
25. The muscles which serve to bring the jaws together, and which, consequently, act most during mastication, are placed on each side of the head, in front of the ear (*Fig* 14.), and when we press the teeth together, we can feel that they contract.

26. In most mammalia the edges of the jaws are armed with teeth.

27. *The teeth are small bodies of great hardness, which resemble bone very much; they are planted in holes, hollowed into the jaws, which holes are named alveoli.*

28. The fibrous pads which cover the edge of the jaws, and which are called *gums*, serve, as well as the alveoli, to fix the teeth solidly in the position which they occupy.

Fig. 15.



29. Generally, each tooth is divided into two parts; one is situated without, and called the *crown*, the other, buried in the alveolus (*Fig.* 15.), and terminated by

Explanation of Fig. 14.—The head seen in profile, to show the parotid gland. (*gp.*) and the chief levator, or elevating muscles of the lower jaw namely, the temporal (*mt.*) and maseter muscles, (*m,m.*)

Explanation of Fig. 15.—Lower jaw of a man opened to show the manner in which the roots of the teeth (*r.*) penetrate its substance (*a.*)—*b.* the superior edge left entire,—*i.* incisor teeth,—*c.* canine teeth,—*fm.* false molar teeth,—*gm.* great molar teeth,—*ed.* condyle of the jaw which enters into its articulation with the cranium.

24. What is the situation of the jaws? Are both jaws equally movable?
25. Where are those muscles placed which move the jaws?
26. Have all animals got teeth?
27. What are the teeth? What are the alveoli?
28. What are the gums?
29. Into what parts is a tooth divided? What is the neck of a tooth?

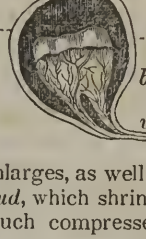
one or more points, is called the root of the tooth. Finally, we often remark between the crown and the root, a slight shrinking, called the *neck of the tooth*.

30. The teeth are composed of an internal substance called *ivory*, and a sort of extremely hard stony varnish, which covers the surface, and is called *enamel*.

31. The crown of the tooth only is covered with enamel. The root has it not.

32. The teeth are formed in the interior of the jaws, and within little membranous pouches called *dental capsules*, which are inclosed within the substance of the bone, and which present in their interior a fleshy *bud*, or granule, from the surface of which exudes the stony matter of which the tooth is composed, (*Fig.* 16.)

Fig. 16.



33. This stony matter is the ivory; it moulds itself upon the *bud*, and takes its form; just in proportion as new quantities of ivory are deposited upon that already formed, the tooth enlarges, as well as the species of case which it forms around the *bud*, which shrinks away until finally the little organ, being too much compressed, disappears; the tooth then ceases to grow.

34. In proportion as the tooth is formed, as we have just said, it rises in the alveolus, passes through the gum, and shows itself without.

35. The enamel is formed at the superior portion of the dental capsule, and is applied upon the tooth just to the extent it traverses that part of the capsule; it is for this reason that the root, which remains at the bottom of the alveolus is never covered by it.

36. The teeth which are formed in the earliest period of life, are destined soon to fall, and to give place to other teeth, stronger

Explanation of Fig. 16.—One of the dental capsules opened to show the fleshy tubercle or granule which is in it,—*b*, the tubercle upon which the tooth in a manner moulds itself,—*v*. blood vessels and nerves which enter into this little secreting organ,—*d*. part of a tooth which has just begun to form,—*c*. capsule.

30. What is the composition of teeth? What is ivory? What is enamel?

31. Have all parts of the tooth a covering of enamel?

32. How are the teeth formed? What are the dental capsules? What do they contain? What office does this granule fulfil?

33. How do teeth grow or increase in size? Do teeth always continue to grow? Does the bud or granule always exist in the tooth?

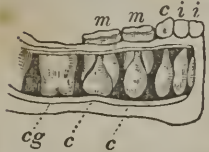
34. How does the tooth rise in the alveolus?

35. Where is the enamel formed? How is it applied to the tooth? Why is there no enamel on the roots of the teeth?

36. Do the teeth of infancy remain through life?

and more solidly fixed. The first are called *milk teeth*, or *deciduous teeth*, or *teeth of the first dentition;* the second, the *permanent teeth*, or *teeth of second dentition*.

Fig. 17.



37. The teeth are divided into three kinds, (*Fig.* 17.) namely:

38. 1st. The *incisive* or *incisor*, which occupy the front of the mouth, and terminate in a thin cutting edge, have but one simple root, and are fit for cutting the various aliments.

39. 2nd. The *canine*, which are placed on each side and next to the incisors, are in general, long and pointed; they also have only a single root, but it penetrates deeply into the jaw; their principal use is to fix themselves in the flesh, upon which the animal feeds, and to tear it.

40. 3d. The *molar* teeth, or *grinders*, which are next to the canine, occupy the sides of the mouth; they are generally, provided with several roots, and present a large, unequal crown, appropriate for grinding the food.

41. The molar teeth are subdivided into false molar, (dentes biscupidati) and great molar; the first are smaller than the second, and are situated in front of them; the roots of the great molars are also more numerous, which gives them more solidity and power.

42. The number of teeth varies in different animals. Man, monkeys, the dog, the cat, &c., have the three sorts of teeth, we have just described; but with the rabbit, the rat, and the other *gnawers*, (*rodentia,*) the canine teeth are wanting; and in other quadrupeds, such as the sloth, there are no incisors; finally, there are also animals that are entirely unprovided with teeth, the ant-eater, and birds, for example.

Explanation of Fig. 17.—The lower jaw of a very young infant, opened to show the capsules of the teeth. The milk teeth are here developed, and there are five on each side: namely, two incisors, (*i,i,*) one canine, (*c.*) and two molars, (*mm.*); we see below them the capsules of the incisor, canine and false molar teeth of second dentition, (*c,c.*) and further back, the capsules of the great molars, (*cg.*)

37. How many kinds of teeth are there?

38. What are the incisor teeth? Where are they placed? What is their peculiar use?

39. Where are the canine teeth? What is their form? What is their use?

40. What is the situation and form of the molar teeth?

41. How are the molar teeth subdivided?

42. Are the same varieties and number of teeth found in all animals? What animals are without teeth?

43. The form of the teeth also varies in different animals, and we remark, that these differences are in accordance with the nature or kind of aliment upon which these beings are destined to be nourished.

44. Thus, with the dog, the cat, and other carnivorous animals, the molar teeth are sharp, and fitted to cut flesh, like scissors (*Fig.* 18.); with the mole and hedge-hog, that live upon pretty hard insects, these teeth are armed with conical points, which dovetail or fit reciprocally, and enable these animals to crush their prey with facility.

Fig. 18.

With the frugivorous animals, monkeys, for example, the same teeth are large, and their crown is armed with rounded elevations, suitable for crushing fruits; and with the ox and horse, which browse or crop the grass, the crown of these teeth is still larger, and its surface is flat and striated like a mill stone. (*Fig.* 19.)

Fig. 19.

45. In man, the deciduous or milk teeth, begin to appear about the sixth or seventh month, and fall about the seventh year. They are in number, twenty; namely, in each jaw:

Four Incisor,
Two Canine, (one on each side,)
And four molar, (two on each side.)

46. The permanent, or teeth of second dentition, are in number, thirty-two.

47. The incisor and canine are the same in number as in the first dentition; but in place of two molars on each side of each jaw, there are five. The total number of molar teeth in adult man is consequently twenty; ten in each jaw.

Explanation of Fig. 18.—Teeth of an animal of the order carnaria,—*i.* incisor,—*a.* canine,—*m.* molar teeth.

Explanation of Fig. 19.—Teeth of an animal of the order rodentia,—*i* incisor teeth,—*m* molar teeth.

43. Is the form of the teeth the same in all animals?

44. Does the form of the teeth of an animal bear any relation to its peculiar food?

45. At what age in man do the first teeth begin to appear? When do they fall? What is the number of the deciduous teeth? What is the number of each kind?

46. What is the number of the permanent teeth?

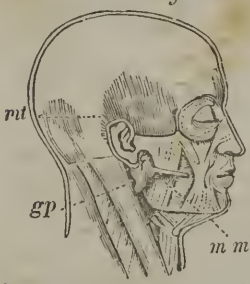
47. How do the permanent differ from the deciduous teeth? How many molar teeth is natural to an adult man?

48. The five molar teeth on each side are divided into two kinds, namely ; two false molars, and three great molars.

OF INSALIVATION.

49. During the act of mastication, the food is mixed with the saliva, which phenomenon is designated under the name of *insalivation.*

Fig. 20.



50. The *saliva* is a watery fluid, colourless and frothy, which is formed in particular organs, called *salivary glands, (Fig.* 20.)

51. In man, these glands are six in number: three on each side of the face, and are called *parotid, sub-maxillary,* and *sub-lingual.*

52. The *parotid* glands are the largest; they are placed beneath the skin, between the ear and the jaw, and empty the saliva into the mouth, by a long straight tube, which opens on the inside or internal face of the cheeks.

53. The *sub-maxillary* glands are smaller than the parotid, and are lodged below and behind the lower jaw.

54. The *sub-lingual* glands are smaller than the preceding, and are found under the tongue.

55. The saliva serves to render the deglutition of food more easy, and contributes to accelerate digestion.

OF DEGLUTITION.

56. The food conveniently prepared by mastication and insalivation, unites upon the back of the tongue in a little mass called an *alimentary ball,* or *bolus.*

57. The alimentary ball is next swallowed. We give the name of *deglutition* to this phenomenon, which consists in the passing of food from the mouth into the stomach, through the pharynx and Œsophagus.

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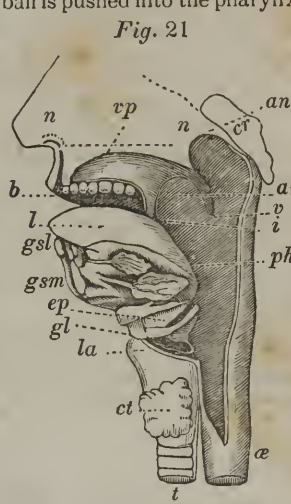
48. How are the molar teeth distinguished?
49. What is insalivation?
50. What is saliva? Where is it found?
51. How many salivary glands exist in man?
52. Where are the parotid glands situated? Where do they open? Which of the salivary glands are largest?
53. What is the situation of the sub-maxillary glands?
54. What is the situation of the sub-lingual glands?
55. What is the use of the saliva?
56. What is the alimentary ball or bolus?
57. What is deglutition?

58. The opening which occupies the back part of the mouth, and which forms the communication between this cavity and the pharynx, is called the *isthmus of the throat*,—*isthmus faucium*. During mastication, it is closed by the *veil of the palate*, (velum palati,) but when deglutition is about to take place, this species of curtain is raised, and the alimentary ball is pushed into the pharynx.

59. The *pharynx*, (*Fig.* 21, *ph.*) is a cavity, situate between the base of the cranium, and the front of the neck; above, it communicates with the nasal fossæ by the posterior nares or nostrils, (*an*), as well as with the mouth, and below it presents two openings; one, by which it is continuous with the œsophagus, the other, situated in front and called *glottis*, by which it communicates with the *larynx* and windpipe. We may compare it to a cross-road where the route followed by the air to get from the nose to the lungs, crosses the route followed by the food to get from the mouth to the œsophagus.

Fig. 21



60. That deglutition may be effected, the alimentary ball must pass *beneath* the posterior nostrils and *over* the glottis, without entering it, and descend directly into the œsophagus.

Explanation of Fig. 21.—A vertical section of the head and neck, to show how the windpipe or trachea opens into the swallow or pharynx, and how this last cavity communicates with the mouth and nasal fossæ or nostrils,—*b.* the mouth,—*l.* the tongue,—*vp.* arch of the palate, which separates the mouth from the nasal fossæ,—*n,n.* nasal fossæ, opening externally by the nostrils and communicating with the swallow by the posterior nares or hind nostrils, (*an.*)—*i.* isthmus of the fauces,—*am.* tonsils.—*v.* veil of the palate,—*ph.* the swallow or pharynx, cleft or divided like the mouth and nasal fossæ, *æ.* œsophagus, a tube which descends from the swallow to the stomach,—*la.* larynx, the superior opening of which, called the glottis, (*gl.*) is placed at the anterior and inferior part of the swallow: we see upon this organ, a species of little tongue or valve, called epiglottis, (*ep.*)—*t.* trachea or windpipe, which descends from the larynx into the lungs,—*cr.* base of the skull,—*gsm.* sub-maxillary gland,—*gsl.* sub-lingual gland,—*ct.* thyroid gland.

58. What is the isthmus of the throat? Is this cavity opened or closed during mastication?

59. What is the pharynx?

60. What is necessary to effectual deglutition?

61. The veil of the palate, by being raised up, and placed obliquely against the posterior wall of the pharynx, forms beneath the posterior nostrils, a sort of screen, which hinders the food from mounting upwards, and entering the nose from behind, during the act of swallowing.

62. That the food may not enter the glottis, it closes at the moment of deglutition, and, at the same time, the larynx is raised up against the base of the tongue, a movement which forces a valve situated above the glottis, and called *epiglottis*, (*Fig*, 21, *ep.*) to fall and close the opening.

63. Sometimes, however, deglutition not being properly effected, the food penetrates into the larynx, and at once brings on a fit of coughing: when this happens, it is said, "we swallow crosswise."

64. The *œsophagus*, or gullet, is continuous with the pharynx: it is a long membranous tube, which descends from the superior part of the neck, behind the windpipe; enters the thorax, passes behind the heart and lungs, pierces the diaphragm, and terminates in the stomach.

65. The pharynx and œsophagus, are furnished with a layer of fleshy fibres which are placed transversely, in rings, which, contracting successively from above downwards, convey the alimentary ball into the stomach.

LESSON VI.

FUNCTIONS OF NUTRITION.—*Stomach digestion, or chymification.—Intestinal digestion, or chylification.—Bile and liver.—Pancreas, and Pancreatic Juice.—Large intestine.—Absorption of chyle.—Chyliferous vessels.—Recapitulation of the functions of nutrition.*

OF STOMACH DIGESTION, OR, CHYMIFICATION.

1. Food begins to be digested in the stomach; it is there transformed into chyme, and we give to this phenomenon the name of stomach digestion, or chymification.

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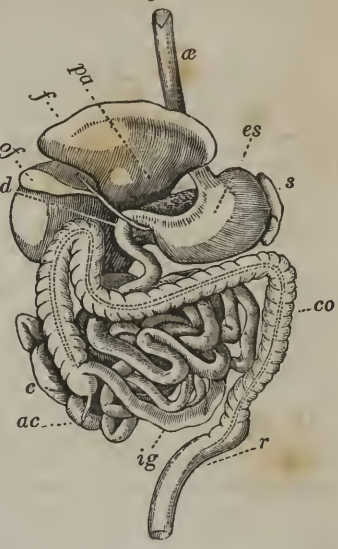
61. What prevents the food from entering into the posterior nares?
62. What hinders food from entering the glottis?
63. What is the effect of food penetrating into the larynx?
64. What is the œsophagus?
65. How is the alimentary ball conveyed into the stomach?

.. Where does digestion commence? Into what is food changed in the stomach? What is the term applied to this change of food?

2. The *stomach*, (*Fig.* 22, *es.*) is a membranous pouch, placed transversely at the superior part of the abdomen or belly. It has the form of a bag-pipe, and presents two openings; one situate to the left, and called *cardia*, (because it is nearest to the heart,) communicates with the œsophagus; the other, called *pylorus*, (from the Greek, *pulouros*, a gate-keeper, because it shuts up the food in the stomach, until converted into chyme,) occupies the right extremity of this organ, and empties into the intestines.

Fig. 22.



3. Immediately after the passage of the alimentary ball, the cardia closes in such a manner as to hinder it from re-ascending again to the mouth. The pylorus is also closed, and the consequence is, that the food is arrested in the stomach, and forced to remain there a considerable time.

4. While the aliment thus sojourns in the stomach, it imbibes a peculiar liquid, called *gastric juice*, which converts it into *chyme*.

5. The *gastric juice* is a watery and acid liquid which is generated in a great number of very small cavities, lodged in the thickness of the parietes, or coats of the stomach, and named *gastric follicles*; each one of these follicles communicates with the interior of this organ by a small pore, and thus empties the gastric juice upon the food.

Explanation of Fig. 22.—Principal organs of digestion,—*œ.* œsophagus, or gullet,—*es.* stomach,—*d.* the duodenum, the first part of the small intestine,—*ig.* the small intestines,—*c.* the cœcum,—*ac.* cœcal appendix, or appendix vermiformis.—*co.* colon,—*r.* rectum,—*f.* the liver,—*of.* the gall bladder.—*pa.* the pancreas,—*s.* spleen.

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2. What is the stomach? What is the cardia? What is the pylorus?

3. What takes place after the alimentary ball passes in the stomach?

4. What is added to the alimentary mass while in the stomach?

5. What is gastric juice? Where is it formed?

6. By the action of the gastric juice, the food is softened and little by little changed into a thick, grayish pap, which is called *chyme.*

7. As soon as the chyme is formed, the pylorus relaxes and the stomach begins to perform a series of movements which, by degrees, push the alimentary mass towards this opening, and then into the intestine. These movements consist in the successive contraction of fleshy fibres which surround the stomach transversely, and which contract, one after the other from left to right.

OF INTESTINAL DIGESTION, OR CHYLIFICATION.

8. The chyme which issues from the stomach enters the intestine where it serves to form chyle.

9. The *intestine* (*page* 67. *fig.* 23.) is a long membraneous tube, folded upon itself, which forms a continuation of the stomach and which, by its opposite extremity, opens outwardly. It is lodged in the abdomen, and is retained in its place by folds of a very fine membrane called *peritoneum*, which lines the parietes or walls of this cavity. The folds of peritoneum which connect the intestines to the spine, bear the name of *mesentery.*

10. The parietes of the intestine are furnished with fleshy fibres which surround them, and which, by contracting successively, push forward the matters contained within this tube. These movements are called *vermiform* or *vermicular*, because they resemble those of a worm when crawling.

11. The length of the intestine is always very considerable, but varies very much in different animals. It is remarked that in those which are nourished by flesh exclusively, it is much shorter than in those which live on vegetable substances: thus in the lion, which is essentially carnivorous, it is only three times the length of the body; while in man, who is omnivorous, its length is about six or seven times that of the body, and in the sheep which eats grass only, it is just twenty-eight times this length.

12. The intestine is composed of two very distinct portions; the small intestine, and large intestine.

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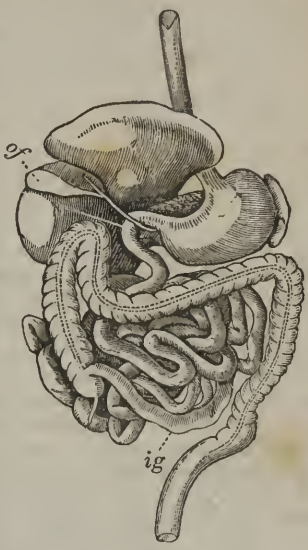
6. What is chyme?
7. What takes place after the chyme is formed?
8. What is formed from the chyme?
9. What is the intestine? Where is it lodged? What retains it in its place?
10. What arrangement enables the intestine to push forward substances within it?
11. In what class of animals is the intestine longest? What is its length in man?

Fig. 23.



13. The *small intestine*, (*Fig* 23, *ig.*) is next to the stomach; it is narrower than the large intestine, and its external surface is smooth. Its length is very considerable, and it is sub-divided into three portions, called: *Duodenum*, *Jejunum*, and *Ilium*.

14. In the small intestine, the chyle is formed, and digestion finished.

15. The phenomenon of chylification is produced by the mixture of the chyme, with the bile and the pancreatic juice.

16. The *bile*, or *gall* is a greenish and very bitter liquid, secreted by the liver.

17. The *liver*, (*Fig.* 22, *f.*) is a large reddish gland, and of a granular tissue. It is lodged in the superior part of the abdomen, to the right of the stomach, and presents upon its inferior surface, a membranous pouch called the *gall bladder*, (*of.*) The bile accumulates in this *bladder*, as in a reservoir, and is afterwards poured into the duodenum by a narrow canal, called the *biliary duct*, or *ductus communis choledochus*.

18. The *pancreatic juice* is a watery liquid which very much resembles saliva; it is formed in a gland, situate behind the stomach, which is called *pancreas*. It reaches the duodenum by a narrow canal, which arises in the pancreas, and empties near the opening of the biliary duct.

19. The chyme, mixed with the bile and pancreatic juice, passes through the whole length of the small intestine; and during

13. What is the small intestine? What are its sub-divisions?
14. What takes place in the small intestine?
15 How is chylification produced?
16. What is bile?
17. What is the liver? Where is it situated? What part receives the bile from the gall bladder.
18. What is pancreatic juice? Where does this pancreatic juice go after leaving the pancreas?
19 What becomes of the chyme after being mixed with the bile and pancreatic juice?

its passage separates into two parts; one called chyle, which is deposited upon the sides of the intestine to be absorbed; the other, composed of those parts of the food which are not nutritious, which continues its route and enters into the large intestine.

OF THE EXPULSION OF THE RESIDUE LEFT AFTER DIGESTION.

20. The alimentary matters which are not convertible into chyle, require to be rejected and conveyed out of the body, and for this purpose they enter into the large intestine, and there accumulate.

21. The *large intestine* is the second portion of the intestinal tube; it differs from the small intestine in its calibre, its puffed form and in its uses. It is divided into three portions; the *cœcum*, the *colon*, and the *rectum*, (*page* 67. *fig.* 23.)

22. The *cœcum* is a swelling, or dilatation wherein the small intestine terminates; we remark there a thin worm-like prolongation, which terminates in a *cul de sac*, or blind canal, and is called the *cœcal appendix,—appendicula vermiformis;* finally, we find on its inside a sort of valve, which hinders the matters contained in its cavity from returning into the small intestine.

23. The *colon* is next to the *cœcum*, and is continuous with the *rectum*, which terminates at the anal opening or fundament.

OF THE ABSORPTION OF CHYLE.

24. The chyle is a peculiar liquid, resulting from the digestion of food, and is deposited upon the parietes of the small intestines.

25. The physical properties of this liquid, vary according to the nature of the food from which it is derived, and according to the animals in which it is observed. In man, and most mammalia, the chyle is generally a white, opaque liquid, very much resembling milk, of an alkaline, saltish taste, and of a peculiar odour. Examined by the microscope, it presents a multitude of globules, analogous to those which form the central nucleus of the globules of the blood. If left at rest, it forms a mass, like the blood, and after sometime, separates into three parts; a solid clot which occupies the bottom of the vessel, a liquid resembling serum, and a thin pellicle, which swims on top, and seems to be of a fatty nature.

20. What becomes of those matters which are not convertible into chyle?
21. What is the large intestine? What are its divisions?
22. What is the cœcum? What is the cœcal appendix?
23. What is the colon?
24. What is chyle?
25. Is the appearance of chyle always the same?

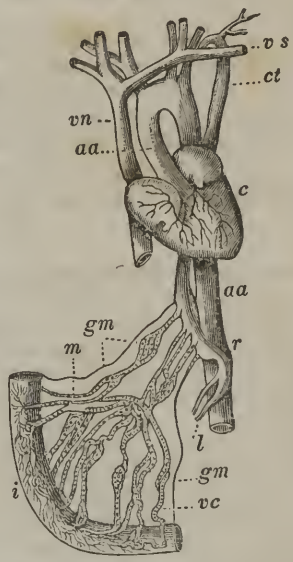
26. The chyle is destined to be mixed with the blood, to repair the losses which this liquid sustains by nourishing the organs; and that this mixture may be effected, it is pumped up by a particular set of vessels which pour it into the veins.

27. This passage of the chyle from the intestine into the circulatory system is known under the name of *absorption of chyle.*

28. The absorption of chyle is performed by the lymphatic vessels of the intestines, which are called for this reason, *chyliferous vessels*, (or *lacteals*, from the appearance they present when filled with chyle.)

29. These vessels, which are extremely delicate, arise (by imperceptible orifices on the mucous membrane that lines the bowel,) from different parts of the small intestine by a multitude of branches, which little by little, unite among themselves, as we remarked of the veins; and after having traversed the small organs, called *mesenteric glands*, empty into a conduit or canal, called the *thoracic duct*, (*Fig.* 24.)

Fig. 24.



Explanation of Fig. 24.—Represents a portion of the small intestine (*i*) upon which we see the chyliferous vessels, the thoracic duct and the course followed by the chyle to reach the veins.—*m.* part of the peritoneum which serves to hold the intestines in their place, and which is called mesentery.—*vc.* chyliferous vessels.—*gm.* mesenteric glands.—*r.* reservoir of Pecquet or receptacle of chyle, which is a slight dilatation of the thoracic duct, soon after its commencement.—*l.* lymphatic vessels coming from all parts of the body to the receptacle of the chyle.—*ct.* thoracic duct which ascends along side the aorta, (*aa.*) passes behind the heart (*c.*) and empties into the left sub-clavian vein. (*v s c*)—*v n.* vena cava, descending to the right auricle.

26. What is the use of Chyle? Into what blood vessels does the chyle enter?

27. What name is given to the passage of chyle into the circulation?

28. How is the absorption of chyle effected?

29. What are the chyliferous vessels? Where do they arise? Where do they empty?

30. This duct, or canal, which also receives the lymphatic vessels from other parts of the body, presents at its inferior extremity, a dilatation called the *reservoir of Pecquet*, or the *receptaculum chyli;* it lies closely glued to the anterior face of the vertebral column or spine, and mounts towards the thorax, to terminate near the base of the neck, in the subclavian vein of the left side.

31. The chyle, in passing through the mesenteric glands seem to be perfected in some degree; it assumes a rosy tint and becomes coagulable like the blood: but it still differs very much from this liquid, and we do not know, with certainty, in what part of the body it is changed into blood.

RECAPITULATION OF THE FUNCTIONS OF NUTRITION.

Such are the different functions by the aid of which the nutrition of the body is effected.

32. The alimentary substances, necessary for renewing the materials of which the organs are composed, are derived, as we have seen, from sources exterior to the animal, and, in order to serve the purposes of nutrition, require to undergo a peculiar preparation to which we give the name of *digestion.*

33. The chief of the functions of nutrition is, consequently, in man as in all other animals, that of Digestion.

34. The nutritious matters, thus elaborated, do not sojourn in the digestive cavity; in order to support the organs, they pass from this cavity into the very substance of the body itself, to be mixed with the blood. To this transportation from without to within, and the passage of all substances from without into the torrent of the circulation, is applied the term Absorption.

35. The blood, to convey in this way, to all parts of the body, materials to repair the organs, must necessarily be the seat of continual currents, and in fact, this liquid finds its way wherever there is life to be supported: this phenomenon is called the Circulation

30. Where is the thoracic duct? Where does it terminate?

31. What change does chyle undergo while passing through the mesenteric glands? In what part of the body is chyle changed into blood?

32. To be available for nutrition what process does food necessarily undergo?

33. What is the chief function of nutrition?

34. What occurs next after digestion?

35. In order to fulfil its office of nourishing the organs, what is necessary to the blood?

36. In acting upon the tissues of the organs, the blood loses a part of its vivifying properties, and in order to regain them, requires to be brought into contact with the atmospheric air, which contact constitutes the phenomenon of RESPIRATION.

37. Finally, the materials separated from the substance of the organs, in consequence of the nutritive movement, are carried along by the blood, and are afterwards separated and rejected from the system in the form of liquids, or of vapours. These acts, which are in a measure, the completion of the nutritive process, bear the general names of EXHALATION and SECRETION.

38. To recapitulate; we see then that the functions of nutrition are constituted of several series of phenomena, each having its seat in different organs, and that these different acts are:

1st. Digestion;
2nd. Absorption;
3rd. Circulation;
4th. Simultaneous decomposition and recomposition of the organs of nutrition, properly so called;
5th. Respiration;
6th. Exhalation and Secretion.

LESSON VII.

FUNCTIONS OF RELATION—*Nervous system and sensibility.*

FUNCTIONS OF RELATION.

1. The phenomena of animal life or life of relation depend upon two faculties: that of sensation and that of motion.

2. These faculties, which do not exist in an equal degree of perfection in all animals, are wanting in vegetables. They are the result of an action of two apparatuses; the apparatus of sensations and the apparatus of motion.

3. The apparatus of sensations is composed of the nervous system and the organs of the senses.

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36. What is the object of respiration?
37. What completes the phenomenon of nutrition?
38. What are the several functions of nutrition?
1. Upon what do the phenomena of the functions of relation depend?
2. Do the faculties of sensation and motion exist in an equal degree in all animals? Do they exist in vegetables? Upon what do these faculties depend?
3. What parts compose the apparatus of sensations?

4. The apparatus of motion is composed of the muscles, of the bones, and of some other organs.

APPARATUS OF THE SENSATIONS.

5. Sensibility is the faculty of receiving impressions from surrounding objects.

6. This faculty has its seat in a particular apparatus called the NERVOUS SYSTEM.

7. It is also through the medium of this nervous system that motion takes place, that the influence of the WILL makes itself felt in different parts of the body, and that the phenomena of intelligence is manifested.

8. We distinguish in this apparatus two principal parts, which are called the nervous system of animal life, and the nervous system of organic life.

9. The *nervous system of animal life* presides over the functions of the life of relation; it is also called the *cerebro-spinal system*, because the brain and spinal marrow are the most important parts of it. (*page* 73 *fig*, 25.)

10. The term *encephalon*, is applied to the great nervous mass formed by these two organs and the other central parts of the nervous system, lodged in the cavity of the cranium and in the canal which exists in the whole length of the vertebral column.

11. The *cranium* is a great cavity which occupies all the superior and posterior parts of the head, and which at the inferior part or base, presents several holes. One of these holes, which is very much larger than the other and placed a little behind, gives it a communication with the *vertebral canal*.

12. The vertebral canal is a cavity hollowed out in the vertebral column or spine, of which it occupies the whole length; it consequently descends from the head, all along the back to the lowest extremity of the trunk and even into the tail, when the animal is provided with an appendix of this sort.

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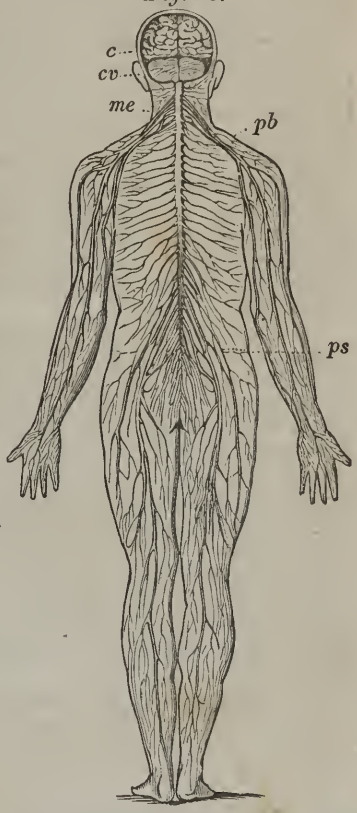
4. What constitutes the apparatus of motion?
5. What is sensibility?
6. Upon what does sensibility depend?
7. Through what means is the influence of the WILL conveyed to different parts of the body?
8. What are the principal parts into which the apparatus of sensation is divided?
9. What is the office of the nervous system of animal life? Why is it called the cerebro-spinal system?
10. What is meant by the term encephalon?
11. What is the cranium?
12. What is the vertebral canal?

When we study the skeleton we shall recur to the description of these parts.

13. The *brain*, or cerebrum (*Fig.* 25, *c.*) is a voluminous viscus, of a very soft texture, and of an oval form, which fills the greatest part of the anterior of the cranium. It is divided on a middle line, by a very deep furrow, into two halves called *hemispheres of the brain.* Each of these hemispheres is subdivided, in its turn, into three lobes, and presents on its surface a great number of hollows and projections, folded on themselves, called the *convolutions of the brain.* We find in the interior, cavities called ventricles, and we distinguish in the substance of which it is composed, two sorts of matter, one white, called medullary, which occupies the interior of the mass of the brain, and the other, of a greyish colour, forms its superficies, and is called cortical.

14. Behind and below the cerebrum, or brain, we find, also in the cavity of the cranium, another nervous mass, very much smaller, but of analogous structure, which is called the *cerebellum.* (*Fig.* 25, *cv.*)

Fig. 25.



Explanation of Fig 25.—The nervous system.—*c.* the cerebrum.—*cv.* the cerebellum.—*me.* the spinal marrow from which arises a great many nerves which ramify over all parts of the body.—*pb.* the brachial plexus or reunion or assemblage of the different nerves which are distributed to the arms.—*ps.* the sciatic plexus or assemblage of nerves which form the great sciatic nerve which descends to the lower extremities.

13. What is the brain? How is it divided? What are ventricles? What is the difference between the medullary and cortical parts of the brain?

14. What does the cranium contain besides the cerebrum?

15. The *spinal marrow*, (*Fig.* 25, *me.*) arises from the inferior part of the brain and cerebellum. It has the form of a thick, whitish cord, and descends from the interior of the cranium to the lowest part of the canal which pierces the vertebral column.

16. We give the name of *medulla oblongata*, to the superior portion of the spinal marrow which is enclosed in the cranium.

17. The *encephalon* (which includes the brain and spinal marrow, also called, the *cerebro-spinal axis*,) is surrounded by different membranes, which serve to prevent it from wounding itself against the sides of the bony case which encloses it. One of these membranes, called the *arachnoid*, is extremely fine; another called the *dura mater*, is, on the contrary, very strong, and in the interior of the cranium forms plaits or folds which descend between the hemispheres of the cerebrum, and between this organ and the cerebellum, to sustain these parts, and prevent them from pressing one upon the other.

18. A great number of soft whitish cords go from the brain and spinal marrow to all parts of the body; they are designated by the name of *nerves*, (*Fig.* 25.)

19. These nerves arise, some from the base of the brain, others from the sides of the spinal marrow. In man there are forty three pairs, of which, the first thirteen arise from the brain and medulla oblongata, and pass out of the cranium through holes in its base: and the remaining thirty pairs arise from the spinal marrow, and go out of the vertebral canal by holes, situate on each side of the spine.

20. The nerves are divided into branches and ramuscles, which are spread out in the different organs, and in them become so extremely fine as to escape our vision. They possess extreme sensibility, and the slightest wound of one of them causes acute pain.

21. The nerves give to different parts of the body to which they are distributed, the sensibility which these parts enjoy. They convey the impressions received by the organs to the brain, which is the seat of the perception of sensations.

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15. What is the spinal marrow?

16. What is the medulla oblongata?

17. What are the coverings of the encephalon? What is the dura mater?

18. What name is given to those cords which go from the brain and spinal marrow to all parts of the body?

19. What is the origin of the nerves? How many pairs of nerves are found in man? What is the origin of the first thirteen pairs of nerves in man?

20. How are the nerves divided? To what part are they distributed? Are they sensible?

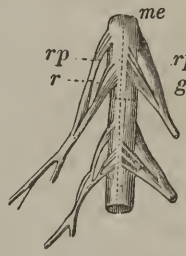
21. What office is performed by the nerves?

It is also through the medium of the nerves that the influence of the WILL is communicated from the brain to different parts of the body, and that motion is performed.

22. Indeed, if we cut the nerves which go to a limb, it becomes immediately insensible, and ceases to execute voluntary motion, or in other words, it is *paralysed*.

23. Certain nerves serve only for the transmission of sensations, others serve only for motion, but the greater part fulfil both these functions at the same time; this arises from the union of a certain number of nervous fibres, of which some possess the first of these faculties, and others the second. At the point where the nerves issue from the spinal marrow, these two species of fibres are still separate, and constitute two distinct roots, one situated before the other (*Fig.* 26.); the anterior root serves for motion, and the posterior for sensibility. When in a living animal we cut the anterior roots of all these nerves, it is incapable of moving, but preserves its sensibility; while if we cut the posterior roots without wounding the anterior, the contrary is true.

Fig. 26.



[The *ganglionic nervous system*, also called the *great sympathetic nerve*, or *nervous system of organic life*, is composed of a number of small, very distinct nervous masses, which are united to each other by medullary cords and different nerves, which anastemose (communicate by branches) with the cerebro-spinal system, or are distributed to the neighbouring organs. These nervous centres bear the name of ganglions: they are found in the head, neck, thorax and abdomen. Most of them are placed symmetrically on each side of a middle line, in front of the vertebral column, and thus form a double chain from the head to the pelvis; but they are found in other parts: near the heart, for example, and in the vicinity of the stomach.]

Explanat. of Fig. 26. *me*—A portion of the spinal marrow, showing the manner in which the nerves arise by two sets or bundles of roots.—*r.* anterior roots serving for motion.—*rp.* posterior roots serving for sensibility.—*g.* ganglionic swelling of a posterior root.

22. What effect would be produced by cutting the nerves which go to a limb?

23. Do all nerves perform the same functions? How is it that some nerves serve for motion and also to transmit sensation? Which nervous roots serve for motion? Which nervous roots serve for sensation? If we cut the anterior roots of the nerves in a living animal what happens? What results from cutting the posterior roots?

24. That sensations may be perceived, it is necessary that the nerves transmit them from the point where they are produced to the brain, either directly, or through the intervention of the spinal marrow.

25. The brain is, at the same time, the seat of the WILL and of the perception of sensations; when, in consequence of a wound or strong compression, this organ cannot perform its functions, the animal becomes insensible, ceases to execute voluntary motions and falls into a state resembling profound sleep.

26. It is remarkable that the nerves which arise from the right side of the spinal marrow communicate with the left hemisphere of the cerebrum and *vice versa;* this results from the crossing of the fibres in the *medulla oblongata*, and hence it is that when the brain is paralysed on one side only, it is the members of the opposite side of the body which lose their sensibility and motion.

27. Farther, the brain, although the seat of perception of sensations, is itself very slightly sensible; we may prick or cut it in a living animal without causing pain.

28. The spinal marrow is, on the contrary, extremely sensible, and when it is wounded, the animal is convulsed; if it be cut or compressed so that it cannot perform its functions, all the parts of the body whose nerves arise below the point of injury are at once paralysed.

29. The cerebellum seems to be designed to regulate motion.

30. The second portion of the nervous system, or NERVOUS SYSTEM OF ORGANIC LIFE, communicates with the nerves which arise from the spinal marrow by a great number of small filaments, but it is distinct from it.

31. This apparatus, which is also designated under the name of *ganglionic system*, or *great sympathetic*, on account of the connection which it establishes between different parts of the body, is composed of a great number of small nervous masses called

24. What is necessary to enable an animal to perceive impressions made upon it?

25. What occurs, if, from any cause, the functions of the brain be interrupted?

26. What is remarkable in the origin of the nerves?

27. Is the brain itself sensible?

28. Is the spinal marrow sensible or not? When the spinal marrow is compressed or wounded, what occurs?

29. What seems to be the office of the cerebellum?

30. Does the nervous system of organic life communicate with the nervous system of relation?

31. Why is the nervous system of organic life called the great sympathetic? Why is it also called the ganglionic system? What is a ganglion? To what parts are those nerves distributed which arise from the ganglions?

ganglions, situated in the neck, in the thorax, and in the abdomen in front of the vertebral column, and tied to each other by communicating cords; a multitude of nerves arise from these ganglions and are spread out in the heart, the lungs, the intestines, the glands and other organs of vegetative life.

32. These parts of the body which receive their nerves from the ganglionic system are slightly sensible, and the movements which they execute are independent of the WILL.

33. The principal nerves of sensibility terminate in particular organs, through the medium of which they receive and transmit to the brain, the sensations produced upon us by surrounding objects. These organs are each destined to receive sensations of a certain kind, and are called organs of the senses.

LESSON VIII.

FUNCTIONS OF RELATION—*Sense of touch—Skin—Hands—Hair—Beard—Nails—Horns—Mode of formation—Sense of smell—Olfactory apparatus—Sense of taste—Sense of hearing—Auditory apparatus.*

1. We give the name of *Senses* to those faculties by the aid of which animals take cognizance of the properties of bodies which surround them.

2. Bodies may differ from each other in different ways; in their weight, their hardness, their volume, their temperature, &c. by their odour, their taste, their form, and their color, or by the sounds which they afford.

3. These various qualities cannot be appreciated by the same organ; the organ which perceives taste for example, is not sensible of the color, or odour of bodies; therefore, the faculty of experiencing sensations from the influence derived from each one of these different kinds of the properties of external objects, is the attribute of a particular organ.

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32. Do the movements of those parts of the body supplied with nerves from the ganglionic system, depend upon the influence of the WILL? Are the parts thus supplied very sensible?

33. How do the principal nerves of sensibility terminate?

1. What are the senses?

2. How do bodies differ from each other?

3. Is any one organ capable of appreciating all the properties of bodies?

4. These faculties or senses, in man and most animals are five in number; namely: *touch*, *taste*, *smell*, *hearing*, and *sight*.

5. Touch and taste are only exercised upon bodies which are brought into contact with those organs which are the seat of those senses. Smell, hearing, and sight, make us acquainted with certain properties of objects at a greater or less distance from us.

6. All animals do not possess the senses in an equal number with man; in some, there is neither organ of sight, nor organ of hearing, nor organ of smell; such is the oyster for example: in others, one or another of these instruments is wanting.

We will now consider each one of the senses, and the organs which are the seat of them.

OF THE SENSE OF TOUCH.

7. Touch is the sense which reveals to us the contact of foreign bodies with our organs and informs us of the nature of their surfaces whether rough or smooth, their movements, the degree of their consistence, their temperature, and, to a certain extent, their form, volume and weight.

8. *Tact* is a passive touch, but this function sometimes becomes active: it is more especially called *touch*, when the sensibility is most exquisite and the surface, which is its seat, can in a manner mould itself to objects.

9. Tactile sensibility is spread out in all parts of the surface of the body, and resides in the *skin*.

10. The skin is the membrane which covers or clothes the body. It is principally composed of two parts, one called the *corium* or *derma*, or true skin, the other, the *epidermis* or cuticle, or scarf-skin.

11. The *epidermis* is the most superficial layer of the skin; it is a sort of thick varnish which covers the derma and serves to protect it against the contact of hard bodies, and prevent it from becoming dry by the action of the air.

12. The derma is the thickest and most important part of the kin; it is beneath the epidermis, and adheres to the subjacent

4. What is the number of the senses? What are they called?
5. What is necessary for the exercise of the faculties of touch and taste? What faculties convey to us notions of bodies without contact?
6. Have all animals the same number of senses as man?
7. What is touch?
8. What is tact? When does it become touch?
9. What is the seat of tactile sensibility?
10. What is the skin? Of what parts is it composed?
11. What is the epidermis? What is the use of the epidermis or cuticle?
12. What is the derma? Where is it placed? Has the derma any nerves? What form the papillæ of the derma? Where is the derma most sensible?

parts by its internal face. A considerable number of nerves are distributed in it, and form upon its surface small elevations called *papillæ*. To these nerves the skin owes its sensibility, which is greatest in those parts where there is the greatrst number of papillæ, as in the ends of the fingers for example.

13. The epidermis is applied upon these nervous papillæ; it is not itself endowed with sensibility, and renders the sense of touch less delicate in proportion to its thickness. Frequent contact with rough and hard substances tends to increase its thickness, thus, the hands of those persons who perform laborious work have the epidermis thicker and less sensible than those whose occupation does not place them in the same circumstances.

14. Hair, beard, nails, horns, &c., are productions formed by small secreting organs, lodged in the substance of the skin; they are developed, like the teeth, by the addition of new portions of their substance upon that already formed, and are not like living organs, the seat of a nutritive movement. We give the name of *bulb*, to the secreting organs of the hair and beard.

15. Finally, there exists in the thickness of the derma, little follicles which secrete the sweat, a liquid which is more or less acid.

16. The contact of an object with any point of the surface of the skin is sufficient to determine a sensation there; but, that touch may be exercised, it is necessary that the part where this contact takes place shall be so formed as to apply itself exactly, and, in a manner, mould itself to the object which the animal wishes to feel; this kind of perfected *tact* has its seat in particular organs called, *organs of touch*.

17. In man, the hand is the special organ of touch, and its structure is admirably well adapted to the exercise of this sense. The fineness of the skin, its great sensibility, the species of cushion formed by the subcutaneous fat at the extremities of the fingers, the length and flexibility of these organs and the capability of opposing the thumb to the other fingers, like a pair of plyers or forceps, are so many conditions essentially favourable to the delicacy of this sense, and enables us to appreciate with great exactitude the qualities of those bodies we may feel.

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13. Is the epidermis itself sensible? What effect has the thickening of the cuticle upon the sensibility of a part?

14. How are hair, beard, horns, nails, &c. produced? What name is given to the secreting organs of the hair and beard?

15. What is the origin of sweat or perspiration?

16. Does contact of an object with any part of the skin determine sensation at that part? Is this contact sufficient for the exercise of the faculty of touch?

17. What is the organ of touch in man? What are the circumstances which render the hand so admirably adapted to its purpose?

18. Most animals have very imperfect instruments of touch, and, in general, the greater part of the surface of their bodies is slightly or not at all sensible, on account of the hairs, feathers, scales, and other hard parts, with which their skins are covered.

OF THE SENSE OF TASTE.

19. Taste is a sense which makes us acquainted with the savor or taste of substances

20. Like touch, taste is exercised by contact only. Its seat is in the mouth.

21. The parts of the mouth where this peculiar kind of sensibility resides are, the edges of the tongue and the arch of the palate.

22. All substances are not sapid; those which are not soluble in water seldom are.

23. In order to act upon the sense of taste, it is necessary that the sapid substances which the animal introduces into its mouth, should be dissolved by the fluids poured into this cavity by the salivary glands, or by some other liquid. It is in a state of solution, that savors are perceived by the nerves of taste, which are spread out upon the surface of the tongue, and which transmit to the brain the impressions of this sense.

OF THE SENSE OF SMELL.

24. The sense of smell reveals to us the existence of odours and enables us to appreciate them.

25. Odours are produced by extremely fine particles, which escape from odorous substances, and which are diffused in the air like a vapour.

26. That odours may act upon the sense of smell, the odoriferous particles must come in contact with the surface of the organ wherein this sense is seated.

27. The sense of smell is exercised in a peculiar apparatus, called the nasal fossæ.

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18. Are most animals well supplied with organs of touch?

19. What is taste?

20. Where is the sense of taste situated? Can this sense be exercised without contact?

21. What parts of the mouth are endowed with the sense of taste?

22. Are all substances sapid?

23. What conditions are necessary to operate on the sense of taste?

24. What is the sense of smell?

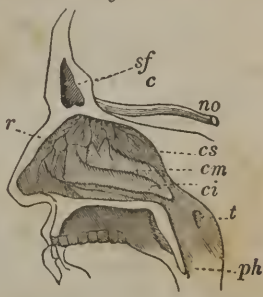
25. How are odours produced?

26. What is a necessary condition in order to act upon the sense of smell?

27. Where is the sense of smell situated?

28. The *nasal fossæ*, (*Fig.* 27.) are two large cavities in the face, which communicate externally by the openings of the nose or nostrils, and open behind, into the pharynx, by the posterior nares or nostrils. The walls of these cavities, form in front, a more or less prominent ridge, which constitutes the nose, and a verticle partition separates one from the other. Finally, they are lined by a soft and very delicate membrane, called the *pituitary membrane.*

Fig. 27



29. The first pair of cerebral nerves which are called the *olfactory nerves*, are distributed to this membrane, and transmit to the brain the impressions produced by the contact of odoriferous particles.

30. The air which traverses the nasal fossæ in order to reach the lungs, carries with it the odorous particles of substances, and it is by touching the pituitary membrane that these particles produce the sensations of smells. The form of the nasal fossæ is such, that the air is carried towards their superior parts, where the greatest number of the delicate filaments of the *olfactory* nerve is distributed.

31. It is vulgarly believed that the humors with which the pituitary membrane is lubricated come from the brain; but this is an error. They are secreted by this membrane itself, and the slight diseases known under the name of cold in the head, *rheum of the head*, are nothing else than inflammation of this membrane.

Explanation of Fig 27.—The nasal fossæ open and seen from the inside.—*c.* the cranium *sf* the frontal sinuses, cavities hollowed out in the substance of the frontal bone, and in communication with the nasal fossæ.—*no.* the olfactory nerve *r.* its branches ramifying on the pituitary or schneiderian membrane.—*cs. cm. ci.* superior, middle and inferior turbinated bones; these are projecting plates of bone which serve to increase the extent of the surface of the organ of smell—*ph.* the swallow or pharynx—*t.* the opening of the Eustachian tube.

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28. What are the nasal fossæ or nostrils? What is the name of the lining membrane of the nose?

29. What nerves are distributed to the pituitary membrane?

30. How is the sense of smells perceived?

31 What is the origin of the humors which cover the pituitary membrane? What disease consists of an inflammtion of this membrane?

OF THE SENSE OF HEARING.

32. Hearing is the sense which enables us to perceive sounds.

33. Sounds are produced by very rapid oscillatory movements, which are manifested in sonorous bodies, and which are called *vibrations.*

34. Sonorous vibrations are communicated, from the bodies in which they are produced, to the surrounding air, and are thus propagated, little by little, or nearer and nearer, like the undulation produced on the surface of smooth water by casting a stone into it.

35. That sounds may act upon our senses, the oscillatory motion must reach the bottom of the apparatus of hearing, that it may agitate the extremity of the nerve, destined to transmit the sensation which it produces.

36. The apparatus of hearing is called the ear; it is double and is symmetrically placed on each side of the head. Each of these apparatuses is lodged in the interior of one of the bones of the cranium, called the *temporal* bone. That part of the temporal bone which contains it, is extremely hard, and for this reason has received the name of *petrous bone.*

37. The apparatus of hearing is very complicated in its structure; it may be divided into three principal parts which anatomists have called the *external ear, the middle ear or cavity of the tympanum*, and the *internal ear*, or *labyrinth*, (*Fig.* 28.)

28. The *external ear* is composed of the *pavilion of the ear*, and the *auditory canal*, (meatus auditorius externus.)

39. The external ear, or pavilion of the ear, (*Fig.* 28, *p.*) is a very elastic cartilaginous plate which surrounds the entrance to the auditory apparatus, and presents, in many animals, the form of a trumpet, which serves to direct sounds towards the interior of the ear. In man, the pavilion of the ear presents many ridges and furrows, or anfractuosities, arising from the folds of the cartilaginous plate which forms it.

40. The *auricular canal*, or *external auditory canal*,—meatus

32. What is the sense of hearing?

33, How are sounds produced? What are vibrations?

34. How are sonorous vibrations propagated?

35. What condition is necessary to produce sensation from sounds?

36. What is the name of the apparatus of hearing? Is it double or single? Where is it situated? What is that part of the temporal bone called which contains the apparatus of hearing?

37. How is the ear divided?

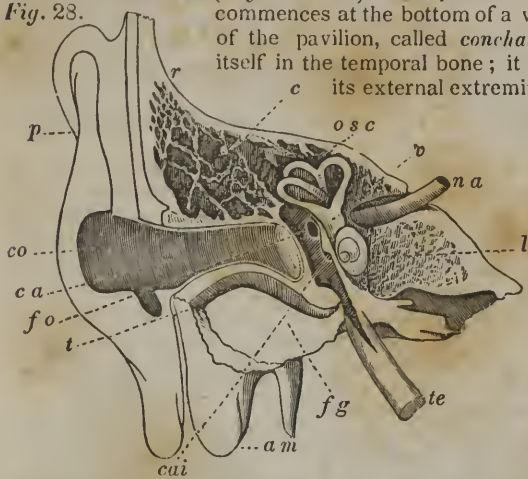
38. What are the divisions of the external ear?

39. Describe the external ear?

40. What is the situation of the external auditory canal? What is the membrana tympani?

auditorius externus, (*Fig.* 28, *c a.*) is a species of tube which commences at the bottom of a widened part of the pavilion, called *concha*, and buries itself in the temporal bone; it is gaping at its external extremity; but ends internally, in a species of membranous partition, named *membrana tympani*,—drum of the ear,—which separates it from the middle ear.

Fig. 28.



41. The *middle ear* is composed of the cavity of the tympanum, and some small accessary parts.

42. The name of *tympanum*, (*Fig.* 28, *cai.*) is given to a small cavity of irregular form which is hollowed out in the petrous portion of the temporal bone, and which is found to lie between the auditory canal and the internal ear. It is filled with air, which gets there through a canal called the *Eustachian tube*, which opens in the superior part of the pharynx.

43. The entrance to the tympanum is closed by a very thin partition, which is stretched like the parchment over a drum, and hence the name, *tympanum*. This membrane serves to facilitate the transmission of sounds from without to the very bottom of the auditory apparatus, and also to moderate the intensity of

Explanation of Fig. 28—A vertical section of the organ of hearing.—*p.* pavilion of the ear.—*co.* concha.—*ca.* auditory canal.—*t.* tympanum behind which is seen the cavity of the tympanum (*cai.*)—*te.* the Eustachian tube.—*fo.* foramen ovale.—*v* the vestibule,—*l.* the cochlea.—*osc.* the semicircular canals—these canals and the cochlea constitute the labyrinth or internal ear.—*na.* the auditory or acoustic nerve.—*r.* the petrous bone, that is, a part of the temporal bone which derives its name from a Greek word signifying, rocky, which has been applied to it from its very remarkable hardness.—*c.* cells in the temporal bone.—*fg.* glenoid cavity for the articulation of the lower jaw.—*am.* mastoid apophysis or mastoid process of the temporal bone.

41. Of what does the middle ear consist?

42. What is the tympanum? Where is it situated? Through what passage does air enter the tympanum?

43. Of what use is the membrana tympani? Does it modify sounds?

sounds; for it is so arranged, that it can be stretched or relaxed; and when stretched, it transmits sounds less perfectly.

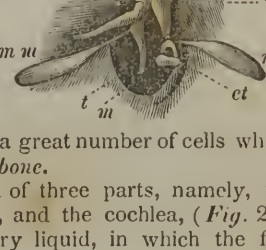
Fig. 29.

44. We also remark in the interior of the tympanum, a transverse chain, formed of four small bones, named on account of their shape, (*Fig.* 29.) the *malleus*, (*m.*) (hammer,) *incus*, (*en.*) (anvil) *lenticular bone*, (*l.*) or *os orbiculare*, and *stapes*, (*st.*) (stirrup.)

45. The malleus rests upon the membrane of the tympanum, and affords attachment to muscles, which, by contracting, may cause it to press more or less strongly upon the membrane; in this way it is stretched or relaxed to adapt itself to the intensity of the sounds by which it is struck.

46. In the interior of the cavity of the tympanum, there are two small openings which are closed up by membranes stretched over them like that of the tympanum; they lead to the internal ear. One of them, called the *fenestra ovalis*, or *foramen ovale*, is in contact with the base of the *stapes;* the other, called the *fenestra rotunda*, or *foramen rotundum*, is situated a little lower down. The cavity of the tympanum also communicates with a great number of cells which are in the substance of the *petrous bone*.

Fig. 30.



47. The *internal ear* is composed of three parts, namely, the vestibule, the semi-circular canals, and the cochlea, (*Fig.* 28.) These organs are filled with a watery liquid, in which the filaments of the acoustic nerve terminate.

48. The vestibule, and the acoustic nerves constitute the essential part of the auditory apparatus; the other parts which we have just enumerated are destined to perfect this apparatus, and for the most part, may be destroyed, even in man, without

Explanation of Fig. 30.—The tympanum with the bones of the ear,—*t.* the tympanum,—*ma.* the maleus or hammer,—*m*, the handle of the maleus, which rests upon the tympanum,—*mm.* muscles of the maleus,—*en.* the incus, or anvil,—*et.* the stapes or stirrup,—*me.* muscles of the stapes.

44. What is found in the interior of the tympanum?

45. What bone gives attachment to the small muscles which act on the membrane of the tympanum?

46. In the cavity of the tympanum are found two small openings; to what part do they lead? Which foramen has the stapes bone attached to it? With what other parts does the cavity of the tympanum communicate?

47. Of what parts is the internal ear composed? With what is these organs filled, and what terminates in them?

48. What essentially constitutes the auditory apparatus?

deafness being the necessary consequence of their loss; they are absent in a great many animals.

49. For example, birds have not the pavilion of the ear; reptiles are destitute of the pavilion, and the auditory canal; in fish all parts of the middle ear, or tympanum, are wanting, and in other animals, such as the craw-fish, the apparatus of hearing consists only of a small vesicle similar to the vestibule.

LESSON IX.

FUNCTIONS OF RELATION.—*Sense of sight—Light—Apparatus of vision—Eye-brows—Eye-lids—Lachrymal apparatus—Muscles of the eye—Structure of the eye—Use of different parts of the eye—Voice.*

OF THE SIGHT.

1. Sight is the sense by which we perceive the form, colour, volume, and position of objects that surround us.

2. This sense, which Buffon called "distant touch," is exercised at a distance, through the medium of light.

3. To comprehend the mechanism of sight, it is not sufficient to know the structure of the eye; we must also be familiar with some of the properties of light, the study of which subject belongs to that branch of science called Optics.

4. Light is a fluid which fills space and illuminates the earth. It emanates from luminous bodies, such as the sun, the fixed stars, and substances in combustion, and diffuses itself afar with inconceivable rapidity.

5. In proportion as the rays become distant from the body from which they emanate, they diverge one from the other, and for this reason bodies are better lighted, the nearer they are to the illuminating body.

6. When light meets with a body, it either passes through it, or is reflected from it, or it may be absorbed.

7. Those bodies which permit light to pass through them are called *transparent*; those which oppose its passage, are called *opaque*.

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49. Is the organ of hearing the same in all its parts in all animals?

1. What is sight?

2. By what means is the sense of sight exercised?

3. Is a knowledge of the structure of the eye sufficient in itself to teach us the mechanism of sight?

4. What is light? What are the sources of light?

5. Why are bodies better lighted when near the illuminating body?

6. When light meets with a body, what takes place?

7. When are bodies transparent? When are bodies opaque?

8. In order to see an object, the rays of light which emanate from it, or which are reflected by it, must reach to the bottom of the eye. For this reason, an opaque body placed between the eye, and the object at which we look, renders the latter invisible.

9. The surfaces of opaque bodies do not always reflect back the light the same as they receive it. As we have said, there are some which absorb all the rays; such bodies are called black. Bodies that reflect all the rays, or nearly all, are white, but those which decompose them, are coloured.

10. Colour is not inherent in bodies; it depends upon the manner in which they decompose the light, and the kind of luminous ray that the coloured body can reflect. Each ordinary ray of light, though it appears colourless to us, is composed of seven differently coloured rays: there is a very simple mode of being convinced of this fact; if we receive a bundle of luminous rays, which have passed through a glass prism, upon a sheet of paper, instead of producing a white image, it will form an oblong image, in which we distinguish the following seven colours, namely: Red, Orange, Yellow, Green, Blue, Indigo, Violet. Now, objects appear to us white, when they reflect the light, without decomposing it, and coloured in this or that manner, when they decompose it like the prism, and absorb some rays and reflect others.

11. In passing through transparent bodies, rays of light sometimes continue to follow their primitive direction: but on other occasions, they change their direction, and approach towards, or diverge from each other. For example, when a straight stick is plunged, half of its length, obliquely into water, it seems as if it were broken; and it is by acting in this way upon light, that the concave or convex glasses of spectacles, enlarge or diminish the images of bodies. This deviation of light is called *refraction*.

12. In order to see a body, the rays of light which part from it, must reach the bottom of the eye, and there paint an image of the object; the impression thus produced, is received by a particular nerve, and by it transmitted to the brain which receives the sensation.

13. The apparatus of sight is composed: 1st. of the organ of vision, which consists of the globe of the eye and its nerve; 2nd.

8. What is necessary to enable us to perceive an object?

9. Do all bodies reflect light? What is the colour of those bodies which absorb all the rays? What is the colour of those bodies which reflect all the rays? What is the colour of those bodies which refract the rays?

10. Upon what does the colour of bodies depend?

11. What is refraction?

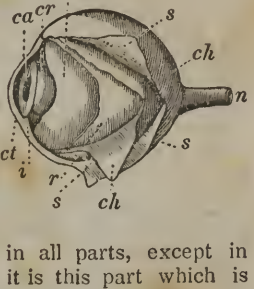
12. In what manner is the image of an object conveyed to the brain?

13. Of what parts is the apparatus of sight composed?

of the accessory organs of vision, that is, of the protectors and movers of the eye.

14. The *globe of the eye*, (*Fig.* 31.) is a hollow ball, filled with certain humors, and so arranged that the rays of light may penetrate it, and collect upon the nerve which occupies its bottom.

Fig. 31.



15. The sides of this globe are composed of a very solid membrane which consists of two parts; one, situated in front, and named *transparent cornea;* the other, occupying the sides and bottom, and called *selerotica*, (*Fig.* 31.)

16. The *sclerotica* surrounds the eye in all parts, except in front; it is white, and entirely opaque: it is this part which is vulgarly called the *white of the eye.*

17. The *transparent cornea* is, on the contrary, diaphanous; it is framed into a great hole in the sclerotica, and resembles a somewhat arched watch-glass, set into a hollow white ball.

18. A short distance behind the transparent cornea, is found a sort of vertical partition, named *iris*, from its varied colours, which are seen through the cornea. Its centre is pierced by an opening which is susceptible of enlargement and diminution; it is called the *pupil.*

19. The space comprised between the cornea and the iris, is called the *anterior chamber of the eye*, which is filled with a transparent liquid called the *aqueous humor.*

20. Behind the pupil we find the *chrystalline lens*, which is a transparent lens of a globular form, and behind the *chrystalline* we find a diaphanous mass soft as jelly, which is called *vitreous humor*, and which fills all the interior of the globe of the eye.

Explanation of Fig. 31.—An open eye,—*s.* the sclerotica, one part of which is turned back,—*ch.* the choroid,—*r.* the retina,—*ct.* the transparent cornea,—*ca.* the anterior chamber,—*i.* the irus, the centre of which is pierced by the pupil,—*cr.* the crystaline lens.—*v.* the vitreous humor,—*n.* the optic nerve.

14. What is the globe of the eye?

15. Of what parts do the sides of the globe of the eye consist?

16. What is the sclerotica?

17. What is the transparent cornea?

18. What is the iris? Why is it so called? What is the pupil?

19. What is that space called which is comprised between the cornea and iris? What does the anterior chamber of the eye contain?

20. What do we find behind the pupil? What is the form of the chrystal line lens? What fills the interior of the globe of the eye?

21. The *optic nerve*, which comes from the brain, enters the globe of the eye through the posterior part of the sclerotica, and then expands itself out into a soft whitish membrane, called *retina*, which envelops the hinder part of the vitreous humor. Between the retina and the internal face of the sclerotica, we find another membrane, generally colored black, called the *choroid*, (*tunica choroides*) It is this coat which is seen through the retina and the humors of the eye when we look towards the bottom o the organ, and which gives to the pupil the appearance of being a black spot instead of a hole.

Such are the different parts which compose the globe of the eye. Let us pass to the consideration of vision.

22. The rays of light which leave an object at which we look, penetrate to the retina and there form a small but very clear image of that object.

23. The manner in which the light acts in the interior of the eye, is the same as in the optical instrument called a *camera obscura*. The different transparent parts through which the luminous rays pass to get from the cornea to the retina, have the effect of collecting the rays and concentrating them upon the retina. It is the chrystalline lens especially that determines this concentration of light, and upon this phenomenon depends the formation of images at the bottom of the eye.

24. When the eye concentrates the light with too much force we cannot see distinctly, except at a very short distance; to this infirmity is applied the term *myopia*, or *short sightedness;* when, on the contrary, the luminous rays are not sufficiently concentrated in their passage through the eye, only distant objects are distinctly seen, and this defect is called *presbyopia* or long-sightedness; this feebleness in the refracting power of the eye, is a consequence of old age, and is remedied by wearing convex glasses before the eyes. To give short-sighted people a longer vision, we must, on the contrary, employ spectacles with concave glasses which scatter the luminous rays, and thus counterbalance the too strong refracting force of the eye.

21. Where does the optic nerve enter the eye? What is the retina? What is found between the retina and internal face of the sclerotica: Why does the pupil seem to be a black spot instead of a hole?

22. On what part of the eye are the images of objects formed?

23. In what manner does light act in the interior of the eye? What effect have the different parts of the interior of the eye upon the light passing from the cornea to the retina? What part especially determines the concentration of light in the eye?

24. What is the consequence of a too great concentration of light by the interior parts of the eye? What is the cause of long sightedness? What kind of spectacles are required for short-sighted people?

25. The iris is contractile, and its principal use is to regulate the quantity of light which should penetrate to the bottom of the eye; when the light is too vivid, it contracts, and consequently diminishes the pupil, through which the rays must pass to reach the retina; in the dark on the contrary the pupil is enlarged.

26. The choroid membrane, which lines the internal face of the globe of the eye, is covered with a sort of black varnish, which absorbs all the luminous rays, not necessary for vision.

27. Images painted, if we may use this term, upon the retina, are transmitted to the brain through the medium of the optic nerve.

28. The accessary parts of the apparatus of vision are of two kinds; the one is designed to protect the globe or ball of the eye, the other to move it and give the required direction to fulfil its functions in the best manner.

29. The protecting organs of the eye are: 1st, the orbit, 2nd, the eye-lids, 3rd, the lachrymal apparatus, 4th, the eye-brows.

30. The *orbit* is a great bony cavity, hollowed out in the face on each side of the nose. It has the form of a cone, the base of which is open and directed forward; its parietes are formed, above by the frontal bone; below, by the superior maxillary bone; externally, or outwardly, by the malar or cheek bone, and internally by the bones which belong partly to the nose. The bottom of the orbit is pierced by a large hole, which communicates with the cranium, and gives passage to the optic nerve.

31. The ball of the eye is set into this cavity and rests upon a sort of cushion formed of fat. It is protected in the same way on all sides except in front, and there we find the eye-lids.

32. The eye-lids are moveable curtains, stretched in front of the ball of the eye. On the outside they are formed of the skin; internally they are lined by a smooth membrane which is reflected over the front of the eye upon the sclerotica, and this membrane is called the *membrana conjunctiva;* between these two membranes—the conjunctiva, and the skin—there is placed a thin plate of fibrous and resisting substance, called *tarsus* or palpebral cartilage, as well as muscles which serve to move these organs. In

25. What is the action of the iris?
26. What is the use of the black covering of the choroid coat?
27. How are images upon the retina transmitted to the brain?
28. What are the uses of the accessary parts of the apparatus of vision?
29. What are the protecting organs of the eye?
30. What is the orbit?
31. Upon what does the ball of the eye rest?
32. What are the eye lids? Of what do they consist? What is their number?

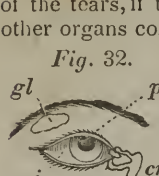
man there are two eye-lids, one superior, and the other inferior. The superior eye-lid is larger than the inferior

33. Each eye-lid has two edges or borders; one is continuous with the skin, the other is free. The free border of the eye lids, is bristled with delicate hairs, called *cilia*, or eye-lashes. The use of the cilia is to form a kind of little grating in front of the eye, to arrest foreign bodies, the presence of which would interfere with the exercise of vision.

34. The eye-lids perform the double office of protecting the ball of the eye, by closing in front of it, and of rendering it inaccessible to luminous rays, the brilliancy of which might disturb sleep. Besides, the eye-lids by their alternate movement of depression and elevation, spread over the front of the globe of the eye, the tears, an aqueous liquid, which prevents the cornea from drying, and also favours the motion of the eye-lids.

35. The *lachrymal apparatus*, which secretes the tears is composed of several organs, some of which are destined to form this liquid, and pour it over the front of the eye; and as the presence of the tears, if too long continued, would become troublesome, other organs convey them from the eye. The first organs, are:

Fig. 32.



36. 1st. The *lachrymal gland*, a small body, the size of an almond, placed at the exterior and superior part of the globe of the eye, between it and the orbitary cavity, (*Fig.* 32, *gl.*); it serves to secrete the tears. 2nd. Several small canals which arise in this gland, and open upon the internal face of the adhering border of the upper eye-lid, where they constantly pour upon the conjunctiva the lachrymal fluid, or tears.

37. The organs destined to carry away those tears which have been spread over the front of the eye, and to convey them into the nasal fossæ, or nostrils, are two little canals which open upon the free border of the eye-lids, near the internal angle of the eye, by two small orifices called the *lachrymal points*,—puncta lachry-

Explanation of Fig. 32.—The eye seen in front,—*p.* the pupil, and *i.* the iris, seen through the transparent cornea,—*gl.* the lachrymal gland,—*pl.* the lachrymal points or puncta lachrymalia,—*cn.* nasal canal.

33. What is the use of the eye lashes?

34. What is the use of the eye lids?

35. What is the use of the lachrymal apparatus?

36. Of what use is the lachrymal gland? How do the tears pass from this gland?

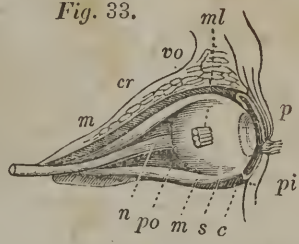
37. What are the puncta lachrymalia? What becomes of the tears after they have moistened the ball of the eye? What is the nasal canal? Explain the phenomenon of crying?

malia, (*Fig* 32.) Each of these points, (which are placed one above, and the other below,) communicate with a little curved canal, which runs inwards, and opens into a vertical conduit, that is larger in size, called the *nasal canal*, and which empties into the nasal fossæ. The function of these lachrymal *puncta* is to pump up and receive the tears as fast as they are poured over the eye: in this way the fluid is carried off as fast as it is formed. Under particular circumstances, the equilibrium between these two phenomena is destroyed; and either that the tears are secreted in too large a quantity, or the lachyrymal puncta do not pump them off with proportioned activity, or they are obstructed in their passage through the lachrymal ducts and nasal canal, this fluid overruns the eye-lids and falls in considerable quantity along the cheeks.

38. The *eye-brows*, which form a ridge above the orbit and are garnished with hairs, also belong to the protecting organs of the eye, but their use is less important than that of those organs of which we have just spoken. They assist in shading the eyes when exposed to strong light.

39. The *motor organs of the eye* consist of six muscles which are fixed, by their anterior extremities into the sclerotica, and by their posterior extremities to the bottom of the orbit, (*Fig.* 33, *m.*) By contracting they direct the ocular globe, to the side where their muscular fibres are placed.

Fig. 33.



40. The apparatus of vision presents nearly the same structure in the mammalia, birds, reptiles, and fishes, but in insects, the organization of the eyes is very different, as we shall see when we come to the history of these animals.

41. Through the medium of the senses we take cognizance of all that surrounds us; but our relations with the external world

Explanation of Fig. 33.—The orbit, opened to show the position of the eye in this cavity, and the muscles which move it,—*cr.* the cranium,—*vo.* the orbitary arch,—*po.* the floor of the orbit,—*p.* and *pi.* the upper and lower eye-lids,—*s.* the globe of the eye,—*c.* the conjunctiva,—*n.* the optic nerve,—*m. m.* two muscles of the eye,—*ml.* a third muscle cut so as to afford a view of the optic nerve.

38. What are the eye brows?

39. What are the motor organs of the eye?

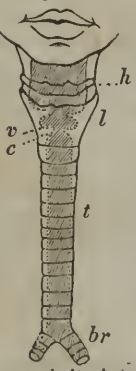
40. Is the organ of vision the same in all animals?

41. What powers are requisite besides the senses, to complete our relations with the external world?

would be very imperfect if we could not act upon these bodies, change place and express what we feel. Indeed, we do possess this power, which is the result of the faculty of producing sounds, and of the faculty of executing motion.

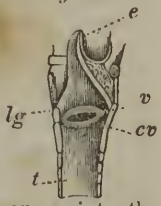
OF THE VOICE.

Fig. 34.



42. Voice consists in the production of a particular sound, by the aid of the air which escapes from the lungs. A great number of organs take part in the performance of this function; but that one which is especially its seat, is the *larynx*, a sort of cartilaginous tube, which, at its superior extremity, opens into the pharynx by an opening named *glottis*, and which, by its inferior opening communicates with the windpipe, which is, in a manner, only a prolongation of it. (*Fig.* 34, *and* 35.)

Fig. 35.



43. The larynx is essentially the organ which produces the voice, and it is the passage of air through its interior which occasions the sounds there formed. To deprive an animal of this faculty, it is only necessary to open the windpipe, for then the air finding an exit through the accidental opening, no longer passes through the larynx, nor is it subjected to the vibrations which would have been imparted by this organ.

44. The larynx, which is composed of several cartilaginous plates, forming in front, what is vulgarly called, *Adam's apple*, is lined by a mucous membrane, which forms, near its middle, two broad lateral folds, directed from the front backwards, and arranged very much like the edges of a buttonhole. These folds are called the *vocal cords*, or *inferior ligaments of the glottis;* by the aid of a little muscle, situate in their folds, the slit, or opening

Explanation of Fig. 34.—The larynx seen in front. The internal line indicates the shape of the internal surface of this organ,—*h.* the hyoid bone,—*l.* the larynx,—*t.* the trachea,—*br*, bronchiæ,—*v.* ventricles of the glottis,—*c.* vocal cords.

Explanation of Fig. 35.—The larynx open, seen from one side,—*e.* the epiglottis,—*v.* one of the ventricles of the larynx,—*cv.* one of the vocal cords,—*t.* the trachea.

42. What is voice? Is voice produced by the function of a single organ?

43. What is the larynx? How may it be proved that the larynx is essentially the organ of voice?

44. What is meant by the vocal cords?

of the glottis, which is between them, can be narrowed or enlarged. Under ordinary circumstances, the air expelled from the lungs, passes freely through the larynx, and produces no sound; but when the opening of the glottis is narrowed, by the contraction of the muscles of this organ, and the passage of the air, becomes more rapid, the voice is heard.

45. Words are produced by the modifications which the column of air receives in the interior of the mouth, by the combined action of the palate, the cheeks, the tongue, and lips.

LESSON X.

FUNCTIONS OF RELATION.—*Apparatus of motion—The skeleton—Structure of bones; their composition—Enumeration of the bones—Articulations—Muscles—Attitudes—Locomotion.*

MOTION.

1. The organs of motion are divided into two classes: 1st. Those which act and produce the *motive* force: 2nd. Those to which the action is communicated; or, in other words, they are divided into the active and passive organs of locomotion.

2. The first are the muscles; the second are the bones or those parts which hold their place.

OF THE OSSEOUS SYSTEM.

3. Man, and all the other mammalia, as well as birds, reptiles and fishes, have in their structure, solid parts which are called *bones*, and the union of these bones, one with the other, constitutes the *Skeleton*. (*page* 97, *fig.* 37.)

4. The skeleton is a kind of frame which gives firmness to the body, in a considerable degree, determines its dimensions and its form, serves to protect the organs which are most important to life, and furnishes the passive instruments of motion to the function of locomotion.

OF THE COMPOSITION OF BONES.

5. The bones are formed of a species of cartilage, composed of gelatine, (the substance which constitutes strong glue,) all the

45. How are words produced?

1. How are the organs of motion divided?

2. Which are the active organs of motion? Which are the passive organs of motion?

3. What are bones? What do they constitute?

4. What is the skeleton? What are its uses?

5. Of what are the bones composed?

laminæ and all the fibres of which are incrusted with a strong matter composed of lime united to particular acids, (phosphoric acid, &c.) When bone is burned, the stony matter remains alone, and is reduced to powder by slight friction, and when bone is steeped in a particular liquid, which has the property of dissolving this stony matter, (hydrochloric acid,) it is reduced to the state of a flexible cartilage.

6. In infancy bone is at first cartilaginous, and before ossification is complete, each one is formed of several distinct pieces, which run together, as it were, at a later period.

7. The bones that constitute the skeleton are united one to the other by *articulations* or joints, which change their name according to their form.

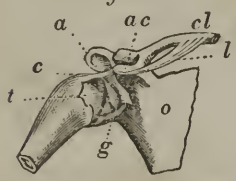
8. If the articulation that unites two bones permits them to move, one on the other, it is called a *moveable* articulation.

9. If on the contrary, the articulation is merely to secure the solidity and firmness of the bones, it is called *immoveable.*

10. The more moveable an articulation, the less solid it is, and *vice versa ;* the more solid, the less mobility it possesses.

11. The immoveable articulations take place through the medium of asperities which dove-tail together; this mode of union is called a *suture.*

Fig. 36.



12. The articular surface of the moveable bones, (*Fig.* 36.) is covered with an elastic substance which is capable of bearing the strongest pressure, and which deadens the shocks they receive; this substance is called *cartilage.* The articulations are also supplied with a viscous fluid called *synovia*, designed

Explanation of Fig. 36.—The articulation (joint) of the shoulder, showing how the moveable bones are attached to each other,—*o.* the scapula.—*t.* the head of the humerus,—*c.* the capsule of the articulation opened,—*g.* glenoid cavity of the scapula,—*a.* the acromion process of the scapula, articulating (jointing with the clavicle, (*cl.*)—*ac.* coracoid process of the scapula,—*l.* ligament extending from this process to the clavicle.

6. What is the condition of bone in infancy?

7. How are bones joined together?

8. What is a moveable articulation?

9. What is meant by an immoveable articulation?

10. What kind of articulation is most solid?

11. What is a suture?

12. How are the articulating surfaces of moveable bones protected from the effects of friction? What is the use of synovia?

to favor the sliding of the articular surfaces upon each other. The extremities of the bones that concur to form an articulation correspond by having their respective configurations reciprocal; they are, in general, one convex, the other concave.

13. The means of union between bones is by fibrous parts which bear the name of *ligaments*. These are very strong bands or species of cords which surround the articulation or joint, holding together the two bones by their extremities.

14. The articulations present a great variety in the motions of which they are susceptible.

15. The bones are also very different in their forms, and on account of this circumstance they are divided into long, short and flat bones.

16. The long bones are generally cylindrical, of considerable size, and in the interior, hollowed into a canal filled with a fatty matter called *marrow;* this form, without injuring their solidity, diminishes their weight. At their extremities these bones are enlarged to afford a broader surface for the articulation.

17. It is easy to perceive that, if the bones were in contact by small surfaces, their union would have been less solid, they would have afforded only an uncertain and insecure motion, and their derangement would have been as common as it is now rare.

18. About their middle, the long bones are formed almost entirely of very compact substance; but at their swollen extremities they are chiefly composed of a spongy substance, which is not so heavy. It is these bones that form the solid frame work of the limbs.

19. Neither the short nor the flat bones have any cavity in the interior.

20. The short bones are formed almost entirely of spongy substance, which lessens their weight without diminishing their volume. The chief use of the flat bones is to form the parietes of cavities which afford protection to internal organs: they are not however, insusceptible of motion; they furnish points of attachment to many muscles.

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13. What are ligaments?
14. Do the articulations permit of a variety of motions?
15. How are the bones divided?
16. What is the general character of the long bones? Where is the marrow found?
17. Why are the long bones enlarged at their extremities?
18. In what respect do the extremities and middle of the long bones differ in structure?
19. Have the short and the flat bones any internal cavities?
20. What is the character of the short bones?

21. We remark inequalities upon the surfaces of bones, which afford points of attachment for muscles; they often present for the same purpose, as well as for the ligaments of the joints, salient prolongations which are named *apophyses* or *processes.*

OF THE SKELETON.

22. The skeleton is a species of frame formed by the union of the different bones of the body. A great many animals are without it, but it exists in the mammalia, birds, reptiles, and fishes.

To study it we will select the skeleton of man (*page 97 fig. 37.*)

23. The skeleton, like the body, is divided into head, trunk, and extremities.

24. The *head* is placed at the superior extremity of the body, and is divided into two parts, the cranium and face.

25. The *face* presents five great cavities destined to lodge the organs of sight, of smell, and of taste: these cavities are the two orbits (*for the eyes*) the two nasal fossæ and the mouth.

26. A great number of bones concur to form the face: the principal ones, are:

1st. The two *superior maxillary* bones, which constitute nearly the whole of the upper jaw, and rise at the sides of the nose to join the frontal bone.

2nd. The *malar* or cheek bones, which form the cheeks in part, and extend from the superior maxillary to the frontal bone so as to complete the orbit on the outside.

3rd. The *inferior maxillary* bone, which constitutes the lower jaw, presents nearly the form of a horse shoe.

There are also other bones in the face called *palate*, *nasal*, *unguiforme* or *lachrymal*, *spongy* bones, and *vomer.*

27. The *cranium* is a bony cavity of an oval form serving to contain the brain. It is formed by the union of several flat bones which are: in front, the *frontal*, upon the sides and above, the *parietal*, behind the *occipital*, below, and on the sides, the *temporal*, and in the middle the *sphenoid*, and inferiorly and in front, the *ethmoid*, which also serves to complete the orbits and form the superior part of the nasal fossæ.

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21. For what purposes are those inequalities which are found on the surfaces of bones? What are processes?

22. What is the skeleton? Is every animal provided with a skeleton?

23. How is the skeleton divided?

24. What is the situation and division of the head?

25. What are the uses of the several cavities of the face?

26. What are the chief bones of the face?

27. Describe the cranium?

Fig. 37.

28. On the sides of the cranium, we remark an opening for the auditory canal, and on its inferior face or base, we find many

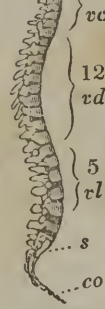
Explanation of Fig. 37.—Skeleton of man; the external line indicates the shape of the body.—*f.* the frontal bone.—*vc.* the cervical vertebræ,—*s.* the sternum, or breast bone,—*co.* the ribs,—*vl.* the lumbar vertebræ,—*a.* the abdomen,—*sa.* the sacrum,—*cl.* the clavicle,—*o.* the scapula or shoulder blade,—*h.* the humerus,—*r.* the radius,—*c.* the cubitus or ulna,—*ca.* the carpus,—*mc.* the metacarpus.—*p.* and *pt.* the phalanges, or bones of the fingers,—*i.* the ilium,—*fr.* the femur,—*ro.* the rotula, patella, or knee-pan,—*ti.* the tibia,—*per.* the fibula,—*ta.* the tarsus,—*mt.* the metatarsus.—*or.* the toes,—*cal* the calcis or heel.

28. Of what use are the several holes at the base of the cranium?

holes which serve to give passage to nerves and blood vessels. One of these holes, very much larger than the others, called the *occipital* hole,—*foramen occipitale*,—corresponds with the vertebral canal, and gives passage to the spinal marrow; and on each side of this great hole we find an eminence called *condyle*, which serves for the articulation of the head upon the vertebral column.

29. The *trunk* is composed of the *vertebral* column, the *ribs* and *sternum*.

Fig. 33.



30. The *vertebral column*, or *spine*, is a species of bony stalk, or stem, which occupies the middle line of the back, and extends from the head to the posterior extremity of the body, (*Fig.* 38.); it is formed by the union of small, short bones, called *vertebræ*, (*Fig.* 39.) and presents throughout its whole length a canal formed by the union of the holes by which each vertebra is pierced; this canal serves to lodge the spinal marrow. Each of these bones presents in front of the hole, a species of thick, solid disc, called the body of the vertebra, which is very firmly united to the body of the vertebra next to it; behind, we remark prolongations called *transverse* and *spinous* processes, which form what is commonly called the *spine*.

Fig. 39.

31. The vertebral column is divided into five regions, namely:

32. 1st. The *cervical* region, which constitutes the frame of the neck: in man, and all the other mammalia, it is composed of seven vertebræ, (*Fig.* 38, *vc.*)

33. 2nd. The *dorsal*, or *thoracic* region, which gives attachment to the ribs which form the *chest*, or *thorax;* the vertebræ of this region in man, are twelve in number, (*Fig.* 38, *vd.*)

34. 3rd. The *lumbar* region, which terminates the back below, in man, is composed of five vertebræ, (*Fig.* 38, *vl*)

35. 4th. The *sacral* region which articulates with the bones of the hips, is composed, in man, of five vertebræ, so run, or fused together, as to form but a single bone called the *sacrum*, (*Fig.* 38, *s.*)

Explanation of Fig. 39.—A vertebra seen from above,—*c.* its body,—*t.* a hole for the passage of the spinal marrow,—*at.* transverse processes,—*sp.* spinal process directed backwards.

29. What parts compose the trunk?
30. What is the vertebral column? What is found in the vertebral canal?
31. Into how many parts is the vertebral column divided?
32. How many vertebræ are found in the cervical region?
33. What is the number of dorsal vertebræ?
34. What is the number of lumbar vertebræ?
35. What is the sacrum?

36. 5th. The *caudal* or *coccygian* region, which in man is composed of four very small vertebræ, concealed beneath the skin, in many animals, is very long, constituting the tail, (*Fig.* 38. *co.*)

37. The vertebral column seen in profile, presents four curves, which correspond to the neck, the back, the loins, and the *pelvis*, or basin, and which serve to augment its solidity. On its sides, we find, between all the vertebræ, a hole which gives passage to a nerve, coming from the spinal marrow.

38. The *ribs*, which are attached to the dorsal vertebræ, are long, flat bones, which enclose the thorax on each side: they are curved and bear considerable resemblance to a half hoop. In man there are twelve pairs. The seven first, called true ribs, articulate in front with the sternum, through the medium of a cartilage; the five last pairs, called false ribs, terminate anteriorly by a cartilage which joins that of the preceeding rib, or they are entirely without cartilage.

39. The *sternum* is a flat bone placed in front of the thorax; it articulates with the ribs and with the clavicles.

40. The *superior* or *anterior extremities* are composed of the shoulder, the arm, the fore-arm and the hand.

41. The *shoulder* is the basis of the whole limb attached to it. It consists of two bones; the *scapula* or shoulder blade, and the *clavicle*, or collar-bone.

42. The *scapula* is a large bone nearly triangular in shape, which is applied against the ribs at the superior and lateral part of the back. At its superior external angle, it presents an enlarged articular surface, slightly hollowed, which receives the bone of the arm and is called the *glenoid cavity of the scapula.* On the posterior face of this bone there is a projecting comb or ridge which extends over the articulation of the shoulder, and articulates with the clavicle. This prolongation is named the *acromion.*

43. The *clavicle* is a long thin bone situated at the base of the neck; it extends like a buttress between the scapula and sternum;

36. What are those vertebræ called which form the skeleton of the tail in animals?

37. For what use are the several holes found between the vertebræ on the sides of the spinal column?

38. What are the ribs? What number of ribs belong to man? How many are true and how many are false ribs?

39. What is the sternum?

40. How are the superior extremities divided?

41. What is the shoulder? What bones compose the shoulder?

42. Where is the scapula placed? What is the glenoid cavity? What is the acromion?

43. What is the use of the clavicle?

and serves to keep the first of these bones in its natural position, and to prevent the shoulder from falling too far forward.

44. The *arm* is formed of a single bone called the *humerus*. This bone is of a cylindrical form and has a swelling at its superior extremity called the head of the humerus which articulates with the glenoid cavity of the scapula. Its inferior extremity is enlarged transversely and resembles a pully upon which moves the fore arm.

45. The *fore-arm* is formed by the union of two bones which are; on the inner side, the *cubitus* or *ulna*, and on the outside, (the side on which the thumb is placed) the *radius*. These bones are joined to the humerus by their superior extremities and to the hand by their inferior extremities.

46. The hand in man is divided into three regions; the *carpus*, the *metacarpus* and fingers; the *carpus* or wrist, is composed of eight small bones, ranged in two rows and united to each other by fibrous threads which preserve their mutual relations and permit them to move a little upon each other, by aid of the smooth surfaces by which they are in contact.

47. The *metacarpus* is composed of five bones which may be regarded as the origin of the fingers. They are placed parallel, one along side of the other; their superior extremities articulate with the bones of the carpus and their inferior extremities with the fingers.

48. The *fingers* are composed of small bones articulated one at the extremity of the other, and called *phalanges*. Except the thumb which has but two, each finger has three of these bones.

49. The *inferior extremities* are formed nearly in the same manner as the superior; the hip represents the shoulder, the thigh the arm; the leg the fore-arm, and the foot the hand.

50. The *hip* or *haunch* serves to support the abdominal member or lower extremity, as the shoulder sustains the thoracic member. It is formed on each side by a very large, and very strong bone, the *ilium*. These bones are united together in front, and behind they articulate with the sacrum, so as to form in conjunction with it at the bottom of the belly, a sort of bony belt called the *pelvis* or *basin*. In infancy, we find that the *ilium* bone consists of three separate portions one of which resembles

44. What is the character of the bone of the arm?
45. How is the fore arm formed?
46. How is the hand divided?
47. What is the metacarpus?
48. How are the fingers composed?
49. How are the inferior extremities formed?
50. What forms the hip? What is the condition of the pelvis in infancy?

the scapula somewhat, and is called the *ilium;* the second, placed in front, called the *pubis*, may, perhaps compare with the clavicle, and the third, situated below and behind, has received the name of *ischium*, and which supports the whole weight of the body when seated; with age these three bones become solidified into one. At the point where they unite, we find a very deep, circular cavity called the *cotyloid* or more commonly the *acetabulum*, in which is articulated the thigh bone.

51. The pelvis serves not only to support the lower extremities, but also assists in sustaining the weight of the viscera contained in the abdomen, and in forming the parietes of this cavity.

52. The *thigh* is formed of a single bone called the *femur*. This bone is articulated by its superior extremity with the hip bone, and by its inferior extremity with the leg.

53. The *leg* is formed of two bones very solidly united to each other. The bone placed internally, very much larger than the other and called *tibia* articulates with the femur by its superior extremity. The bone which is placed externally does not quite reach to the femur, and is only united to the tibia; it is named *fibula*. In front of the articulation of the leg with the thigh is placed a small bone named *rotula* or *patella*, which is designed to strengthen the knee joint.

54. The *foot* is divided into three regions; the *tarsus*, the *metatarsus* and *toes*. It differs from the hand chiefly in the shortness of the fingers, that is, toes, their limited mobility and by the disposition of the tarsus.

55. The *tarsus* is constituted of the union of seven bones, one of which alone, called the *astragalus*, articulates with the two bones of the leg; another one of these bones, called the *calcis*, forms a considerable projection behind which constitutes the heel.

56. The *metatarsus* is composed of five bones which are united to the tarsus and to the bones of the toes, and which are arranged like the bones of the metacarpus.

57. Like the fingers, the *toes* are composed of p' alanges. called first, second, and third phalanges. The great toe has but two phalanges, each of the others has three. All these little

51. What are the uses of the pelvis?
52. What number of bones is in the thigh?
53. How many bones constitute the leg? What are they called? What is the patella?
54. How does the foot differ from the hand?
55. What constitutes the tarsus?
56. Of what bones is the metatarsus composed?
57. Of what bones are the toes composed?

bones are joined to each other by articular surfaces, the contact and junction of which are secured by fibrous ligaments.

OF THE MUSCLES.

Fig. 40.

58. All the great motions of the body are caused by the displacement or movement of some of the bones which form the skeleton; but these bones cannot move of themselves, and only change their position through the action of other organs attached to them, which, by contracting, draw the bones after them.

59. These motor organs are the *muscles.* They are very numerous and constitute what is commonly called flesh, and form nearly one half of the total mass of the body. They are a species of ribbon or fleshy cords composed of fasciculi or bundles of fibres united together, and which have the property of contraction or elongation, (*Fig.* 40.) All the muscles destined to produce the great movements of the body, are fixed to the skeleton by their two extremities. It, therefore, follows, that when they contract they displace those bones which offer the least resistance, and draw them towards those which are not moveable, but serve as points of support for moving the first. Now, in most instances, the bones are more moveable in proportion as they are more distant from the centre of the body: and the muscles which are fixed between two bones, generally act upon that which is most distant, and we always find the muscles, destined to move a bone, extend from it towards the trunk; for example, the muscles which move the fingers, occupy the palm of the hand, and the fore-arm; those which flex the fore-arm upon the arm, occupy the arm, and those which move the arm on the shoulder, are placed upon the shoulder, (*Fig.* 40.)

Under ordinary circumstances, however, the muscles displace the bones which serve them as points of support. When the body is suspended by the hands, and we endeavour to raise it, the flexor muscles of the fore-arm, not being able to displace the latter, approximate the arm, and thus draw the whole body after it.

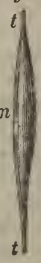
Explanation of Fig. 40.—The muscles of the superior extremity,—*d.* the deltoid muscle, which extends from the shoulder to the arm, and by contracting, elevates the latter,—*b.* the biceps muscle which bends the arm,—*f.* one of the flexor muscles of the fingers.

58. How are the great motions of the body produced?
59. What are muscles?

Figs. 42. 41.

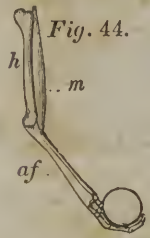
60. When a muscle contracts, it swells; its fibres, which in a state of repose, were straight, fold in zig-zag, (*Figs.* 41, *and* 42.) and their two extremities are brought near to each other, drawing also with them the parts to which they are attached, but their volume is not augmented.

Fig. 43.



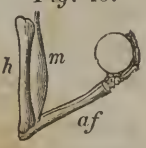
61. The two extremities of muscles are solidly fixed to the bones, and to the other parts which they are designed to set in motion, such as the skin, through the medium of white cords, called *tendons*, (*Fig.* 43.) or membranes of the same nature, named *aponeuroses*, or *fasciæ*. In contracting, they must necessarily draw towards each other the two bones to which the tendons or aponeuroses are attached. An example will enable us better to understand this mechanism.

Fig. 44.



If we suppose the muscle, *m*. (*Fig.* 44.) to be attached to the humerus, and to the ulna or cubitus, which articulates with the first, forming the elbow joint, by moveable ligaments, it is evident that when this muscle contracts, these bones will approach each other, as is seen in Fig. 45. This example will give an idea of all the motions of the skeleton.

Fig. 45.



62. The number of muscles of the human body is very considerable; they are reckoned at 470; in general, they form about the skeleton two layers, and are distinguished into superficial and deep seated.

63. The muscles which are designed to move any particular bone, are almost always placed around that portion of the skele-

Explanation of Fig. 41.—A fragment of muscle showing the muscular fasciculi (bundles of muscular fibres,) straight, and at rest.

Explanation of Fig. 42.—The same in a state of contraction.

Explanation of Fig. 43.—A muscle (*m.*) with the tendons, (*t, t.*) by which it is attached to the bones.

Explanation of Fig. 44.—Bone of the arm (*h.*) and the fore-arm, (*af.*) with one of the flexor muscles of the fore-arm (*m.*) in a state of rest.

Explanation of Fig. 45.—The same at the moment of contraction.

60. What changes take place by the contraction of a muscle?

61. To what parts are the extremities of the muscles attached? What is the necessary consequence of the contraction of a muscle?

62. What is the disposition of the muscles? How are they distinguished?

63. How are the muscles situated in regard to the parts they are destined to move?

ton which is situated between the bone to be moved and the centre of the body; for example, the muscles which move the head are situated on the neck; those which move the arm are on the shoulder; those which flex and extend the fore-arm surround the humerus, and those which flex and extend the fingers are placed upon the fore-arm; the same is true of the muscles of the lower extremities.

64. The muscles are divided into *flexors*, *extensors*, *rotators*, *elevators*, &c. according to the uses which they subserve.

65. The contraction of the muscles is determined by the action of the nervous system, and each muscle receives a nerve which is ramified in its substance.

66. This contraction is sometimes effected through the influence of the Will and sometimes independently of it.

67. The muscles whose action is dependent upon the Will belong to the functions of relation, and those whose motions are involuntary (the heart for example) belong to the functions of vegetative life.

68. The strength or power of a muscle depends partly upon its volume, and partly on the manner of its attachment to the bone which it moves.

69. All things being in other respects equal, the strongest muscles are the largest, and from exercise both their volume and strength are at the same time increased.

70. In the bodies of animals, the muscles and the bones are generally placed unfavourably for the power of motion, but very favourably for rapidity, as may be easily demonstrated by the elementary principles of mechanism.

71. The muscles not only serve to enable us to execute different motions, but they are also equally necessary to maintain the moveable bones in the positions proper to them, and their action determines the attitudes.

For example, the head by its own weight has a tendency to fall forward, but the contraction of the muscles on the back of the neck keep it erect.

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64. How are the muscles divided?

65. What determines the contraction of the muscles?

66. Is muscular contraction always the result of the influence of the will?

67. To what principal functions do the muscles belong?

68. Upon what does the strength or power of a muscle depend?

69. What is the effect of exercise upon the muscles?

70. Whether are the muscles and bones arranged more with a view to power or rapidity?

71. Do the muscles serve any other purpose than to produce motion?

OF THE ATTITUDES.

72. The term *attitude* is applied to any position of the body that is permanent during any considerable time.

[In order to explain the mechanism of the attitudes it will be necessary to enter into some of the details which properly belong to the study of physics.

73. All bodies when left to themselves, tend towards each other, from the influence of a general force called *attraction*, and the force with which one body attracts another, is great in proportion as its mass is larger comparatively than that of the attracted body.

74. Now, the mass of the earth being incomparably larger than that of the animals, plants, stones, and all other objects spread upon its surface, attracts them unceasingly, and tends to cause them to fall towards the centre of the globe.

75. In order that a body shall rest in the position it occupies, it must be sustained by something capable of resisting this force of attraction, and which does not give way under its weight, such as the solid surface of the earth itself, or an inflexible body placed between it and this surface.

76. We name, *base of support*, the space occupied by the points by which an object supports itself upon a resistant body, or the space comprised between these points.

77. In order that a solid body shall rest motionless or immovable, upon its base of support and not fall, it is not necessary that all its parts should be thus sustained; it is enough to sustain it by a single point, provided this point be placed in such a manner that if a part of the mass fall towards the earth, another part opposite to it and of equal weight, be elevated as much; the weight of one part counterbalancing the other. *Centre of gravity* is the name given to the point about which all points of a body reciprocally balance each other, and if it be sustained, it is sufficient to maintain the entire mass in place.

78. It follows then that to prevent a body from falling, it is sufficient that its base be placed vertically beneath its centre of gravity.

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72. What is meant by attitude?
73. What is attraction?
74. Why do all bodies tend to fall towards the centre of the globe?
75. What condition is necessary that a body may preserve its position?
76. What is meant by base of support?
77. What is meant by centre of gravity?
78. What is necessary to prevent a body from falling?

79. It is also easy to understand that its equilibrium will be more stable in proportion to the extent of its base; for then its centre of gravity may be more displaced, without the vertical line which passes through the centre of gravity, being carried beyond the limits of this base of support.

The more the centre of gravity is elevated above the base of support, the less firm on the contrary will be the equilibrium, for a smaller displacement from this point will then suffice to carry the vertical line, that descends from it, beyond the base of support which soon causes the body to fall.]

The term *attitude* is applied to any position of the body that is permanent during any considerable time.

80. The principal attitudes of man are: lying, sitting, and the erect position on his feet, or standing.

81. When a man is lying on his back or on his belly, all parts of the body rest upon the earth: he is not then required to contract any muscle to keep them in place, and his position unites in the highest degree the two conditions of equilibrium, to wit; the greatest possible extent of the *base of support* and the proximity of the *centre of gravity* to this base. Hence the attitude of repose is that from which it is most difficult to fall.

82. In the sitting position the body rests upon the tuberosities of the ischium or haunch bones; the base of support is considerable, since it is represented by the pelvis, the extent of which is increased by the soft parts which cover it; this position also, next to lying, offers the greatest solidity; but it cannot be preserved without muscular action. When the back is supported, the muscles of the neck alone contract to preserve the head erect; but if the back is not supported (as when seated on a stool or a bench for example) then the greater part of muscles on the back of the trunk contract to prevent it from falling forward, and fatigue will sooner or later result from this permanent action.

83. When man is erect, the lower extremities sustain the body and transmit to the earth the weight which they support. Consequently these limbs must not bend under the load, and must be kept straight by the contraction of their extensor muscles.

84. In this position the centre of gravity of the whole body lies in the cavity of the pelvis, and the base of support is circum-

79. Why is a body firm in proportion to the extent of its base?
80. What are the principal attitudes of man?
81. What position or attitude is preserved without muscular exertion?
82. What muscles are exerted to preserve the sitting position?
83. What supports the body when man is erect?
84. Where is the centre of gravity in the erect position? Where is the base of support in the erect position?

scribed by the space comprised between the two feet. Here a slight force is sufficient to destroy the equilibrium, and it is only by enlarging the base of support in one direction more than in another that a fall can be prevented.

The movements by which we regain the perpendicular in the base of support are in a measure automatic. Thus, to resist a force tending to make us fall forward the foot is rapidly advanced: if the body leans to the left we suddenly extend the right arm to re-establish the equilibrium, if a force tends to throw us backward, we put a foot behind and throw the body in advance. The man who has a large belly and the man bearing a heavy load upon his shoulders are both obliged to assume attitudes that change the position of the centre of gravity. The first carries the body backwards in order that the vertical line passing through this point may also fall between the two feet, and for the same reason, the second bends the body forward. A woman who carries an infant upon her right arm inclines the body to the left side: thus, we are constantly resorting to mechanics, even without possessing the most elementary notions of the science, and the most certain causes of our preservation are found in the continual application of physical laws, of which our reason has not the knowledge.

When an animal rests upon its four members at the same time, his standing is more firm, more solid and less fatiguing: for the base of support is then very large. Then, without inconvenience the feet may be much smaller than in the bipeds and consequently lighter.

OF LOCOMOTION.

85. The objects of the motions which we perform is either to change the position of certain parts of the body, or to transport us from one place to another.

86. The faculty of changing place is called *locomotion.*

87. The movements of progression by the help of which man and animals change place, are produced by certain parts of the body which being flexed, rest upon a resisting object, and being again immediately extended, push forward the rest of the body.

88. In man the organs of locomotion are the abdominal members, or lower extremities; in quadrupeds the thoracic as well as the abdominal members; and in birds that fly, the wings.

89. In *walking*, the body of man is moved alternately by one

85. What is the object of the motions which we perform?
86. What is meant by locomotion?
87. How is progression effected?
88 What are the organs of locomotion?
89 How is walking distinguished from running and leaping?

of the feet and sustained by the other, without his ever ceasing completely to rest on the ground. This last circumstance distinguishes walking from leaping and running, movements in which the body quits the earth for a moment and launches into the air.

90. In walking, one of the feet is carried forward, while the other is extended on the leg, and as this last member is supported on the ground, its elongation displaces the pelvis and throws the whole body forward. When the foot which was advanced alights upon the ground, the pelvis turns on the femur of that side, and the leg which was at rest behind, is flexed and carried front of the other, touches the earth and in its turn serves to sustain the body, while the other limb by being extended gives a new impulse to the pelvis. By the aid of these alternate movements of flexion and extension each limb in turn bears the weight of the body, as it would do when standing on one foot, and at each step the centre of gravity of the whole mass of the body is pushed forward.

Security in walking is always in a direct ratio to the degree of separation of the feet, and in an inverse ratio to the mobility of the surface that supports us. It is only at the end of a certain time that sailors walk securely upon the deck. When they have once "got their sea legs" it is very easy to recognise them on shore from the habit which they have of considerably separating the feet in walking.

91. *Leaping* or jumping is a movement by which a man projects himself into the air and again falls to the ground as soon as the effect of the impulsion is lost.

92. The mechanism of the leap consists entirely in the previous flexion of the joints and their sudden extension. When a jumper wishes to spring, he shortens himself by folding himself up as it were upon himself; the leg is flexed forward on the foot, the thigh is also flexed back on the leg, and the trunk with the pelvis are flexed forward on the thigh; and, when one wishes to spring with all his strength, the trunk is flexed upon itself like a spring. In these preliminaries of the leap, the lower extremities and the body describe a series of zigzags. At the moment of the leap all the articulations are extended at the same instant and raise the body with such rapidity that it leaps into the air like an elastic rod that had been bent to the ground, and then suddenly abandoned to its elasticity or spring.

90. What is the mechanism of walking?
91. What is leaping?
92. What is the mechanism of a leap?

93. It is easy to perceive that the parts which act most in the leap are the legs: indeed, it is upon them that the weight to be raised is most considerable. The facility and rapidity of the leap are always in direct ratio to the energy of the muscles, which determine the extension of the legs. It is observed that the most vigorous dancers and even great walkers have the calf strongly developed: indeed this part is formed of the muscles which effect the extension of the leg upon the foot.

94. Running partakes both of walking and leaping. There is always a moment in running when the body is suspended in the air, a circumstance which distinguishes it from rapid walking in which the foot that rests behind does not leave the ground until the forward one again touches it.

95. Swimming and flying are movements analogous to those of leaping, but which take place in water or in the air, fluids whose resistance to a certain extent, takes the place of that of the ground in the act of leaping.

96. When an animal is destined to live in water and to swim, its members have a different form from that of those animals which are organized for walking only. The limbs are then short and constitute a species of paddles or oars called *fins*. When the animal is designed to elevate himself in the atmosphere, the thoracic members on the contrary are very much expanded and are so arranged on each side of the body as to form a kind of moveable sail or fan, fit to strike the air with force.

In one of the following lessons, when we consider the mammalia and birds, we shall recur to the study of these organs, and we shall see how the same members may constitute in different animals, the instruments of prehension, of walking, of natation, or of flight.

We here conclude what we proposed to say generally, on the manner in which the principal phenomena of animal life are performed, and on the organs which serve as instruments for the exercise of the faculties with which animals are endowed.

We shall next proceed to study each of these animals in particular, and see in what way they differ from each other

END OF ANATOMY AND PHYSIOLOGY.

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93. What is remarkable in the legs of great dancers and walkers?

94. What is the mechanism of running?

95. What are swimming and flying?

96. What is the character of those animals which are destined to live in water? What is the character of the limbs of those animals destined to elevate themselves in the air?

PHYSIOLOGY.

GLOSSARY.

Abdomen.—From the Latin, *abdere*, to conceal; the belly. The chief viscera contained in the abdomen, are the stomach, intestines, liver, &c. &c.

Absorption.—From the Latin, *absorbere*, to suck up. The function of absorbent vessels, by virtue of which they take up substances from without or within the body.

Acetabulum.—From the Latin, *acetum*, vinegar. From its resemblance to the ancient Greek vinegar vessel, called *oxybaphon*. (See Cotyloid.)

Acoustic.—From the Greek, *akouô*, I listen. Relating to sounds.

Acromion.—From the Greek, *akros*, extreme, and *ômos*, the shoulder. The superior prominence of the scapula, that joins to the clavicle, forming the bony point of the shoulder.

Adult.—One arrived at maturity—full grown.

Aliment.—From the Latin, *alimentum*, which is formed from *alere*, to nourish. Any substance, which, if introduced into the system, is capable of nourishing it, and repairing its losses. Food.

Alveolus.—Latin. The hole in which a tooth is placed.

Alveoli.—Plural of alveolus. Sockets of the teeth.

Anatomy.—From the Greek, *ana*, through, and *temnô*, I cut; the description of the structure of animals. The word anatomy properly signifies *dissection;* but it has been appropriated to the study and knowledge of the number, shape, situation, structure, and connexion, in a word, of all the apparent properties of organised matter, whether animal or vegetable.

Anatomical.—Relating or belonging to anatomy.

Analogous.—From the Greek, *ana*, between, and *logos*, reason. Having some resemblance or relation though differing in essential particulars. Similar.

Analysis.—From the Greek, *analuô*, I dissolve. The separation of bodies into their component parts.

Anfractuosity.—From the Latin, *anfractus*, the bending or winding of a way in or out. A groove or furrow—used in anatomy to signify sinuous depressions, of greater or less depth, like those that separate the convolutions of the brain.

Animal.—From the Latin, *animalis*—a name given to every animated being provided with digestive organs.

Animalcule.—From the Latin *animalculum*—a diminutive animal.

Animalcula.—Plural of animalculum—animals that are only perceptible by means of the microscope.

Annelides.—A class of animals without vertebræ.

Anus.—Latin. The fundament—the inferior opening of the bowels.

Aorta.—From the Greek, *aorte*, a vessel. The great artery which arises from the left ventricle of the heart, and conveys the blood to all parts of the body.

Aortic.—Relating to the aorta.

Aponeuroses.—From the Greek, *apo*, from, and *neuron*, a nerve. (The an-

cients called every white part *neuron*.) Membranous expansions of muscles and tendons are so called.

Apophysis.—From the Greek, *apo*, from, and *phuô*, I rise. An eminence or process of bone.

Apparatus.—Latin, *ad*, for, and *parare* to prepare; a collection of instruments or organs for any operation whatever. An assemblage of organs.

Appendix.—Latin, *ad*, to, and *pendere* to hang; something added. Any part that adheres to an organ, or is continuous with it.

Arachnides.—From the Greek, *arakne*, a spider. Insects of the genus of spiders.

Arachnoid.—From the Greek, *arakne*, a spider's web, and *eidos*, resemblance. A thin, transparent membrane, which covers the brain.

Artery.—From the Greek, *arteria*, formed according to some, from *aer*, air, and *terein*, to preserve, because it was anciently believed that the arteries were filled with air, like the windpipe. The vessels which convey blood from the heart to all parts of the body, are called arteries.

Arterial.—Belonging or relating to an artery.

Articulate.—From the Latin, *articulus*, which is the diminutive of *artus*, a limb, which is derived from the Greek, *urthron*, a joint. To join or joint. To form words, to utter.

Articulation.—A joint.

Asphyxia.—From the Greek, *a*, privative, and *sphuxis*, pulse. Suspended animation.

Asphyxiate.—In a state of suspended animation.

Astragalus.—Name of the bone of the foot which articulates with the tibia in the ankle joint.

Astronomy.—From the Greek, *astron*, a star, and *nomos*, law. The natural history of the heavenly bodies.

Atmosphere.—From the Greek, *atmos*, vapor, and *sphaira*, a sphere or globe. The air which surrounds the earth.

Auditorius.—Latin. Belonging or relating to the sense of hearing.

Auricle.—From the Latin, *auricula*, which is the diminutive of *auris*, an ear. The two auricles of the heart, derive the name from their resemblance to ears.

Auriculo-ventricular.—Relating or belonging both to an auricle and ventricle.

Automatic.—From the Greek, *automatus*, self-moved, spontaneous, which is formed from *autos*, himself, and *maô*, I desire. *Automatic movements*, are those which depend on the structure of the body, and are independent of the will, such as that of respiration, the circulation of the blood, &c.

Axillary.—From the Latin, *axilla*, the arm-pit. Belonging or relating to the arm-pit.

Azote.—From the Greek, *a*, privative, and *zôe*, life—*without life;* because *azote* will neither support animal life, nor combustion. A gas which is unfit for respiration. It is one of the component parts of the atmosphere. It is also called nitrogen.

Bile.—A yellow, greenish, viscid, bitter, nauseous fluid, secreted by the liver, to aid in the process of digestion. The gall.

Bolus.—Latin. A mass, lump, or mouthful. A ball.

Botany.—From the Greek, *botane*, a plant. The natural history of plants.

Brachial.—From the Latin *brachium*, an arm. Belonging or relating to the arm.

Branchiæ. — Latin. It is derived from the Greek, *bragchos*, the throat. The gills of fishes. They are the respiratory organs of fishes, and are very different from lungs, both in their form and structure.

Bronchiæ.—From the Greek, *bragchos*, the throat. The two branches of the wind-pipe which convey air to the lungs.

Calcis. — Latin. Genitive of *calx*, the heel.

Camera.—Latin. A chamber.

CANINE.—From the Latin, *canis*, a dog. The name of certain teeth.

CAPILLARY.—From the Latin, *capillus*, hair. Hair-like, small. The *capillary vessels* are the extremely minute terminations of the arteries and commencing branches of the veins.

CAPSULES, (Dental,)—Membranous pouches in which the teeth are formed.

CARDIA.—From the Greek, *kardia*, the heart. The left opening of the stomach, where the œsophagus enters it.

CAROTID.—The great arteries of the neck, which convey blood to the head, are so called.

CARPUS.—From the Greek, *karpos*, the wrist. The part between the forearm and hand.

CARTILAGE.—Gristle. A solid part of the animal body of medium consistence between bone and ligament.

CAUDAL.—From the Latin, *cauda*, a tail. Belonging or relating to the tail.

CAVA.—Latin. Hollow. *Vena cava*, the hollow or deep seated vein. A name given to the two great veins of the body, which meet at the right auricle of the heart.

CEREBELLUM.—The diminutive of *cerebrum. The little brain.* The inferior portion of the brain contained in the cranium.

CEREBRO-SPINAL.—Belonging or relating to both the cerebrum and spine.

CEREBRUM.—The brain. The term is sometimes applied to the whole contents of the cranium; at others, to the upper portion; the posterior and inferior being called *cerebellum.*

CERVICAL—From the Latin, *cervix*, the neck. Belonging or relating to the neck.

CHOROID.—From the Greek, *chorion*, (the skin,) and *eidos*, resemblance. The name of several vascular membranes. A thin membrane of a very dark colour, which lines the sclerotica internally.

CHOROIDES.—Choroid.

CHYLE.—From the Greek, *chulos*, nutritious juice. A nutritive fluid of a whitish appearance, which is extracted from food by the action of the digestive organs.

CHYLI.—Latin. Of Chyle.

CHYLIFICATION.—From the Latin, *chylus*, chyle, and *facere*, to make. The formation of chyle by the digestive processes.

CHYME.—From the Greek, *chumos*, juice. A kind of grayish pulp, formed from the food after it has been for some time in the stomach.

CHYMIFICATION.—From the Greek, *chumos*, juice, and the Latin *facere*, to make. The formation of chyme.

CILIA.—Latin. The eye-lashes.

CLAVICLE.—From the Latin, *clavis*, a key. The collar-bone.

COCCYGIAN.—Relating to the coccyx, which is an assemblage of small bones appended to the sacrum: if prolonged, it would constitute a tail.

COCHLEA.—Latin. A snail-shell. The name of one of the three cavities which form the labyrinth of the ear.

CŒLIAC.—The name of one of the arteries of the abdomen.

CONCHA.—The hollow part of the cartilage of the external ear.

CONDYLE.—From the Greek *kondulos*, a knot, an eminence, a bump. A small round eminence of bone entering into the composition of an articulation.

CONJUNCTIVA.—Latin. Formed from *con*, with, and *jungere*, to join. The mucous membrane which covers the anterior surface of the ball of the eye, and unites it to the lids.

CORIUM.—The skin.

CORNEA.—One of the coats of the eye, so called, because it has some resemblance to horn. It forms about one fifth of the anterior part of the eye.

COTYLOID.—From the Greek, *kotule*, a drinking cup, and *eidos*, resemblance. The name of a hemispherical cavity in a bone of the pelvis, which receives the head of the thigh bone, forming the hip joint. It is also called the *acetabulum.*

CRANIUM.—From the Greek, *kranon*, head. The skull.

CRUSTACEA.—From the Latin, *crusta*, a crust. A class of animals whose bodies are inclosed in a covering, like the crab.

CUBITAL.—Relating to the cubitus.

CUBITUS.—Latin. One of the bones of the fore-arm, which is also called ulna.

DECIDUOUS.—From the Latin, *cadere*, to fall. Falling, that which falls off—not permanent.

DEGLUTITION.—From the Latin *deglutire*, to swallow. The act by which substances are passed from the mouth into the stomach, through the pharynx and œsophagus.

DERMA.—Greek. The skin.

DIAPHANOUS.—From the Greek, *dia*, through, and *phainein*, to shine. Permitting the passage of light.

DIAPHRAGM.—From the Greek, *diaphragma*, a partition. The fleshy or muscular partition, between the cavity of the chest and cavity of the abdomen.

DIASTOLE.—From the Greek, *diastellô*, I open, I dilate. The dilatation of the heart and arteries when the blood enters their cavities.

DORSAL.—From the Latin, *dorsum*, the back. Belonging or relating to the back.

DURA.—Latin. Hard. *Dura mater* is a dense membrane, which covers the brain, lying between it and the skull.

ENCEPHALON.—From the Greek, *eg*, in, and *kephale*, head. The brain and spinal marrow.

EPIDERMIS.—From the Greek, *epi*, upon, and *derma*, skin. The external covering of the derma. The cuticle or scarf-skin.

EPIGLOTTIS.—From the Greek, *epi*, upon, and *glôttis*, the glottis. A species of cartilaginous valve, situate at the upper part of the larynx, behind the base of the tongue. It closes at the moment of swallowing, and thus assists in preventing the passage of alimentary substances into the air tubes.

ETHMOID.—From the Greek, *ethmos*, a sieve, and *eidos*, resemblance. The *ethmoid bone*, so called because its upper plate is pierced by a considerable number of holes, is situate at the base of the cranium betwixt the orbits.

EXCRETION.—From the Latin, *excernere*, to separate. The separation or throwing off of those matters from the body of an animal which are supposed to be useless, as perspiration, &c. The matters thrown off from the body as useless, are termed excretions.

EXCRETORY.—An *excretory vessel*, or *duct*, is one which transmits the fluid secreted by a gland, either externally or into the reservoirs, in which it has to be deposited. *Excretory organ* means any organ charged with the office of excreting: thus, the skin is said to be an excretory organ, because through it the perspiration or sweat is *excreted*.

EXHALATION.—From the Latin, *exhalare*, to throw out, to exhale—That which exhales from any body. A function, by the virtue of which certain fluids obtained from the blood are spread, in the form of dew, on the surface of membranes, either for the sake of being thrown out of the body, or to serve for certain purposes. The sweat is an example of an exhalation as well as of an excretion.

EXTEND.—To straighten; to stretch out. When a limb is straightened it is said to be extended.

EXTENSOR.—A muscle whose office it is to extend certain parts.

EXTERNAL.—Outside. It is used in relation to the middle line of the body; for example, the little toe is external, and the big toe internal; the corner of the eye next to the nose, is the *internal* corner, and the other the external corner of the eye.

EXTERNUS.—Latin. External.

EXTREMITIES.—The limbs; the legs and arms.

Fascia.—Latin. Formed from *fascis*, a bundle. The aponeurotic expansions of muscles which bind parts together, are so termed.

Fasciæ.—Plural of fascia.

Fauces.—Latin. The swallow or gorge.

Faucium.—Latin. (The genitive case, plural of *faux*. (See Isthmus.)

Femoral.—Relating to the femur.

Femur.—Latin. The thigh-bone.

Fenestra.—Latin. A window,—an opening or hole.

Fibre.—An organic filament, of a solid consistence, and more or less extensible, which enters into the composition of every animal and vegetable texture.

Fibril. } A very small fibre.
Fibrilla. }

Fibrous.—Composed of fibres. Belonging or relating to fibre.

Fibula.—Latin. A clasp, a brace. The name of the long, small bone, situate at the outer part of the leg: it assists materially in holding the foot in its proper position.

Filament.—From the Latin, *filamentum*, which is the diminutive of *filum*, a thread. A very small fibre —a fibril.

Fissure.—From the Latin, *fissura*, which is formed from *findere*, to cleave. A long narrow cleft or opening.

Flex.—To bend.

Flexion.—The state of being bent.

Flexor.—A muscle whose office it is to bend certain parts

Follicle.—From the Latin, *follis*, a bag. A diminutive glandular sac, or bag.

Foramen.—Latin. A hole.

Foramena.—Latin. (Plural of foramen.)—Holes.

Fossa.—Latin. From *fodio*, I dig. A cavity of greater or less depth, the entrance to which is always larger than the base. The *nasal fossæ*, are two large irregular cavities, situate between the orbits below the cranium and behind the nose. The nostrils.

Function.—From the Latin, *fungor* I act, I perform. The action of an organ or set of organs. We see, for example, by the *function* of the eye, and the *function* or action of the ear enables us to hear.

Ganglion.—From the Greek, *gagglion*, a knot. Nervous ganglions are enlargements or knots in the course of a nerve.

Ganglionic.—Consisting of ganglions Relating to ganglions.

Gas.—Any substance or fluid which is *permanently* aëriform under the ordinary conditions of the atmosphere.

Gastric.—From the Greek, *gaster*, the stomach. Belonging or relating to the stomach.

Genus.—Latin. A kindred, breed, race, stock, lineage, or family.

Genera.—Plural of genus.

Generic.—Belonging or relating to genus.

Geology.—From the Greek, *ge*, the earth, and *logos*, a discourse. A description of the structure of the earth.

Glenoid.—From the Greek, *glene*, the pupil, and *eidos*, resemblance. Any shallow articular cavity, which receives the head of a bone.

Globule.—From the Latin, *globulus*, a small globe.

Glottis.—A small oblong aperture, situate at the upper part of the larynx.

Hemisphere—From the Greek *emisus*, half, and *sphaira*, sphere or globe. One half of a sphere or globe, or globular body; the brain is divided into two hemispheres.

Humerus.—The bone of the arm, which is situate between the shoulder joint and the elbow.

Iliac.—From the Latin, *ilia*, the flank. Relating or belonging to the flank or ilium.

Ilium.—The haunch-bone.

Incisor.—From the Latin, *incido*, I cut. The teeth which occupy the anterior part of the upper and lower jaws, are called *incisors*, or incisor

teeth, because they are used for *cutting* the food in the manner of cutting instruments.

INSECT.—From the Latin, *insectum*, which is formed from *secare* to cut. The generic name of small animals whose body is, as it were, divided or *cut* into several parts; as the chest and belly. Insects have neither a circulating apparatus, nor vertebræ; but they possess an apparatus for breathing, have jointed extremities, and generally have wings.

INTERCOSTAL.—From the Latin, *inter*, between, and *costa*, a rib. That which is situate between the ribs.

INTERNAL.—See External.

INTUSSUSCEPTION.—From the Latin, *intus*, within, and *suscipio*, I receive. The mode of increase peculiar to organised bodies.

ISCHIATIC.—From the Greek, *ischion*, the haunch. An epithet applied to parts connected with the haunch.

ISCHIUM.—The hip bone—the seat bone.

ISTHMUS.—Latin. Formed from the Greek, *isthmos*, a narrow tongue of land, joining a peninsula to a continent. Anatomists have given the name *isthmus faucium*, isthmus of the fauces, to the strait or passage between the mouth and pharynx.

JUXTAPOSITION.—From the Latin, *juxta*, near to, and *ponere*, to place. The mode of increase, proper to minerals, which is by the successive addition of new matter on the outside of that which already existed. It is opposed to *intussusception*.

LABYRINTH.—From the Latin, *labyrinthus*, which is formed from the Greek *laburinthos*, a place full of turnings, the exit of which is not easily discoverable. Anatomists have given this name to the aggregate of parts, constituting the internal ear.

LACHRYMAL.—From the Latin, *lacryma*, a tear. Relating to the tears.

LACHRYMALIA.—Latin. Belonging or relating to the tears.

LAMINA.—Latin. A plate, or thin piece of metal or bone.

LAMINÆ.—Latin. Plural of Lamina.

LARYNX.—From the Greek, *larugx*, a whistle. The apparatus of voice. It is situate at the superior and anterior part of the neck; and at the top of the trachea, with which it communicates.

LEVATOR.—A muscle whose office it is to raise or elevate certain parts.

LIGAMENT.—From the Latin, *ligare*, to tie. A name given to fibrous structures, which serve to unite bones, and form articulations.

LOBE.—A round projecting part of an organ.

LUMBAR.—Relating to the loins.

LYMPH.—A name given to the fluid contained in the lymphatic vessels, and thoracic duct of animals.

LYMPHATIC.—Partaking of the nature of lymph. Relating or belonging to lymph.

MALAR—(bone.)—From the Latin, *malum*, an apple; so called from its roundness. The cheek bone.

MALLEUS.—Latin. A hammer.

MAMMALIA.—From *mamma*, a breast. Animals that suckle their young.

MAMMALOGY.—From the Latin, *mamma*, breast, and the Greek, *logos*, a discourse or treatise. That part of Natural History which treats of mammiferous animals.

MAMMARY.—From the Latin, *mamma*, a breast. Belonging or relating to the breast.

MAMMIFERÆ—From the Latin, *mamma*, a breast, and *fero*, I carry. Animals that have teats.

MAMMIFEROUS—Belonging or relating to mammiferæ.

MATER.—Latin. Mother.

MEATUS.—Latin. A passage.

MEDULLA.—Latin. Marrow.

MEMBRANA.—Latin. A membrane.

MEMBRANE.—A name given to different thin organs, representing species of supple, more or less elastic, webs.

MEMBRANOUS, or Membraneous.—Belonging to membrane

Mesentery.—From the Greek, *mesos*, in the middle, and *enteron*, an intestine. A term applied to several duplicatures of the peritoneum, which maintain the different portions of the intestinal canal in their respective situations; allowing, however, more or less mobility.

Mesenteric.—Relating to the mesentery.

Metacarpus.—From the Greek, *meta*, after, and *karpos*, the wrist. That part of the hand which is between the wrist and fingers.

Metatarsus.—From the Greek, *meta*, after, and *tarsos*, the instep. That part of the foot which is between the instep and toes.

Meteorology.—From the Greek, *meteôros*, a meteor, and *logos*, a discourse. The natural history of the atmosphere.

Mineralogy.—From the Latin, *minera*, a mineral or mine, and the Greek *logos*, a discourse. The natural history of minerals.

Mitral.—Of the form of a mitre, or bishop's bonnet. The name of two valves of the heart.

Molar.—From the Greek, *mulos*, a millstone or grindstone; or from the Latin, *molo*, I grind. That which bruises or grinds. The name of certain teeth.

Molar Teeth.—The grinders. Jaw teeth.

Mollusca.—From the Latin, *mollis*, soft. A class of marine animals without vertebræ, which have blood vessels, a spinal marrow, and a simple body, without articulated limbs.

Molluscous.—Relating to Mollusca.

Motor. } That which moves, or
Motive. } gives the power to move.

Myopia.—From the Greek, *mus*, a mouse, and *ops*, sight. Because mice were supposed to be short-sighted. Nearsightedness.

Nares.—Latin. The nostrils.

Nasal.—Relating to the nose.

Nitrogen.—From the Greek, *nitron*, nitre, and *gennaô*, I beget. The name given to azote on account of its being the acidifiable base of *nitric* acid.

Nutrition.—The function by which the various organs receive the nutritive substances, necessary to repair their losses and maintain their strength.

Oblongata.—Latin. Elongated—lengthened.

Obscura.—Latin. Dark—obscure.

Œsophagus.—From the Greek, *oiô*, I carry, and *phagô*, I eat. The gullet. A tube leading from the mouth to the stomach for the transmission of food.

Olfactory.—From the Latin *olfactus*, the smell. That which belongs or relates to the sense of smell.

Orbiculare.—Latin. Orbicular.

Orbit.—From the Latin, *orbis*, a circle. The circular cavities are so called, which lodge the organs of sight.

Organ.—From the Greek, *organon*, an instrument. Part of an organised being, destined to exercise some particular function; for example, the ears are the organs of hearing, the muscles are the organs of motion, &c.

Organic.—Relating to an organ.

Organised—Composed of organs; having a mode of structure.

Os.—Latin. Bone.

Ossification.—From the Latin, *os*, a bone, and *facere*, to make. The formation of bone.

Ovalis. } Latin. Oval.
Ovale. }

Oxygen.—From the Greek, *oxus*, acid, and *geinomai*, I engender.—*The generator of acid*, as it was believed to be *exclusively*, when this name was given to it. A gas which constitutes about one fifth of our atmosphere; which is necessary to the respiration of animals, and consequently indispensable to animal life. But it cannot be breathed alone for any considerable time with impunity, requiring to be mixed with about four parts of nitrogen or azote, as is the case in

our atmosphere, to render it suitable for respiration.

PALATI.—Latin. (The genitive case of *palatum*.) The palate.

PALPEBRAL.—From the Latin, *palpebra*, the eye-lid. Belonging or relating to the eyelid.

PANCREAS.—From the Greek, *pan*, all, and *kreas*, flesh, that is, *quite fleshy*. A gland deeply seated in the abdomen, which resembles the salivary glands in its structure, and has been called the *abdominal salivary gland*. It is this part of the calf which is called, in common language, the sweet bread.

PANCREATIC.—Relating to the pancreas.

PAPILLÆ.—Plural of Papilla.

PARIETES.—From the Latin, *paries*, a wall. A name given to parts, which form the inclosure—the limits of different cavities of the body.

PAPILLA.—Latin. A nipple. A name given to small eminences, which appear to be formed by the ultimate expansion of the vessels and nerves.

PAROTID.—From the Greek, *para*, about, and *ous*, the ear. The parotid gland is the largest of the salivary glands, seated under the ear, and near the angle of the jaw.

PATELLA.—Latin. (The diminutive of *patina*, a dish, so called from its shape.) The knee pan.

PELVIS.—Latin. A basin. The name of the bony structure at the lower part of the trunk, which forms the inferior boundary of the abdomen, gives support or place of foundation to the spinal column, and affords points of articulation for the thigh bones, constituting the hip-joint.

PERICARDIUM.—From the Greak, *peri*, around, and *kardia*, the heart. The pericardium is a membranous sac, which envelopes the heart, and the arterial and venous trunks that pass from, or into it.

PERITONEUM —From the Greek, *peri*, around, and *teinô*, I stretch. A serious membrane which lines the abdominal cavity, and covers entirely or in part all the organs contained in it, and by folds, maintains them in their respective relations. The peritoneum is a sort of sac without aperture, which covers the abdominal organs, without containing them within it; the internal surface of this sac is smooth, and lubricated by a serous (watery) fluid.

PETROUS.—From the Greek, *petra*, a rock, a stone. A part of the temporal bone, which contains the internal organs of hearing, is so called from resembling a stone in hardness.

PHALANGES —The plural of Phalanx.

PHALANX.—From the Greek, *phalagx*, a file of soldiers. The bones composing the fingers and toes. They are named first, second, and third phalanges.

PHARYNX.—From the Greek, *pharugx*, the pharynx. The swallow. The superior opening of the Œsophagus.

PHENOMENON.—From the Greek, *phainomai*, I appear. Appearance; visible quality.

PHENOMENA.—Plural of Phenomenon

PHILOSOPHY.—From the Greek *phileô*, I love, and *sophia*, wisdom or knowledge. A clear and distinct knowledge of things. The pursuit of truth.

PHYSIOLOGY.—From the Greek, *phusis*, nature, and *logos*, a discourse. The science which treats of the functions of animals or vegetables.

PORTA.—Latin. A gate. The part of the liver, where its vessels enter as by a gate. The *vena porta* is a vascular apparatus, which conveys black blood to the liver.

PREHENSION.—From the Latin, *prehendere*, to lay hold of. The prehension of aliment consists in laying hold of, and conveying food into the mouth.

PRESBYOPIA.—From the Greek, *presbus*, an old man, and *ops*, an eye—Longsightedness.

PRIMER.—From the Latin, *primus*, first. An elementary book—a first book.

PROCESS.—From the Latin, *procedo*, I go before—an eminence of bone—an apophysis.

PUBIS.—The anterior and middle part of the pelvis.

PULMONARY.—Belonging or relating to the lungs.

PUNCTA.—Latin. Plural of *punctum*. Points.

PYLORUS.—From the Greek, *pule*, a gate, and *ouros*, a guardian. The lower or right orifice of the stomach

RADIAL.—Belonging or relating to the radius.

RADIUS.—Latin. A spoke—so called from its shape—one of the bones of the fore-arm.

RAMUSCULE.—From the Latin, *ramus*, a branch. A diminutive branch.

RECEPTACULUM.—Latin. A receptacle—a reservoir.

RENAL.—Belonging or relating to the kidney.

RETINA.—From the Latin, *rete*, a net. The essential organ of vision: on it the images of objects are impressed.

ROTATOR.—From the Latin, *rota*, a wheel. A name given to muscles, which turn the parts to which they are attached on their axes.

ROTULA.—The patella.

ROTUNDUM. } Latin. Round.
ROTUNDA. }

SACRAL.—Relating to the sacrum.

SACRUM.—The bone which forms the posterior part of the pelvis, and is a continuation of the vertebral column.

SALIVA.—Spittle.

SALIVARY.—Belonging or relating to saliva.

SAP.—The nutritious liquid, or blood of plants.

SCAPULA.—The shoulder blade.

SCIENCE.—From the Latin, *scientia*, knowledge. Any art or species of knowledge, arranged in order, or on some plan.

SCLEROTICA.—From the Greek, *skleroó*, I harden. A hard, resisting, pearly white, opaque membrane, which forms the posterior four fifths of the external coat or covering of the eye ball.

SECRETION.—From the Latin, *secernere*, to separate. The organic functions of the several glands, by which they separate from the blood the materials which they respectively demand for their several purposes: each organ according to its peculiar structure, differs from the rest, and hence we have the formation of the different fluids, as bile, saliva, milk, &c. The fluids thus elaborated or separated from the blood are also termed secretions.

SENSE.—The faculty of receiving impressions from external objects.

SENSIBILITY.—The ability or faculty of receiving impressions from surrounding objects, and being conscious of them.

SINUOUS.—Relating or belonging to a sinus. Partaking of the nature of a sinus.

SINUS.—Any cavity, the interior of which is more expanded than the entrance; in this respect, being the reverse of a *fossa*; which see.

SKELETON.—From the Greek, *skellô*, I dry. The aggregate of the hard parts of the body, or the bones.

SKIN.—The dense, elastic membrane, which envelopes the body. It consists of three layers or laminæ; the *derma*, the *epidermis*, and *rete mucosum*, the last being situate between the other two. The colour of the different races of men depends upon the colour of this *rete mucosum*, (mucous net;) the other two layers being alike or nearly so, in the whole human family.

SPHENOID.—From the Greek, *sphen*, a wedge, and *eidos*, resemblance—a bone, situate on the middle line and at the base of the cranium. It articulates with all the other bones of the cranium; supports them, and strengthens their union, acting very much like the key-stone of an arch.

STAPES.—Latin. A stirrup. The innermost of the small bones of the ear, so called because it resembles a stirrup.

Sternum.—From the Greek, *sterros*, solid. The breast bone.

Subclavian.—From the Latin, *sub*, under, and *clavis*, the clavicle. That which is under the clavicle.

Subcutaneous.—From the Latin, *sub*, under, and *cutis*, the skin. That which is under the skin.

Sublingual.—From the Latin, *sub*, under, and *lingua*, the tongue. That which is under the tongue.

Submaxillary.—From the Latin, *sub*, under, and *maxilla*, the jaw. That which is under the jaws.

Suture.—From the Latin, *suo*, I stitch. A kind of immoveable articulation or joint, in which the bones unite by means of serrated edges, which are, as it were, *dove-tailed* into each other. The articulations of the bones of the cranium are of this kind.

Symmetrical.—From the Greek, *sun*, with, and *metron*, measure. A term applied to those parts of the body, which if seated on the middle line, may be divided into two equal, and perfectly like halves: or which, if situate—the one to the right and the other to the left of this line—have a similar conformation, and a perfectly analogous arrangement.

Syncope.—From the Greek, *sugkoptô*, I fall down. Fainting—complete loss of sensation and motion, with considerable diminution or *entire* suspension, of the pulsations of the heart and the movements of respiration. Hence, syncope resembles death.

Synovia.—From the Greek, *sun*, with, and *ôon*, an egg. The lubricating fluid of the joints, which enables the surfaces of the bones and tendons to glide smoothly over each other.

System.—From the Greek, *sun*, together, and *istemi*, I place. An arrangement according to some plan or method.

Systole.—From the Greek, *sustellô*, I contract. The contraction of the heart, by which it gives impulse to the blood or causes its progression in the blood vessels. It is opposed to the *diastole* of this organ.

Tarsus.—From the Greek, *tarsos*, any row, the sole of the foot. The posterior part of the foot, which, in man, consists of seven bones, and forms the heel and instep. A thin plate of cartilage seated in the substance of the free edge of each eyelid.

Tears.—The fluid secreted by the lachrymal gland, and poured between the globe of the eye and the eyelids, to facilitate the motions of those parts.

Tendon.—From the Greek, *teinô*, I stretch. Strong, white, fibrous, cords, which connect the muscles to the bones which they move. The tendons may be considered as so many cords, for transmitting the motion of the muscles to the bones or levers.

Tendinous.—Belonging to, or partaking of the nature of tendon.

Thorax.—From the Greek, *thôrax*, the chest. It is bounded posteriorly by the vertebræ; laterally, by the ribs and scapula; anteriorly, by the sternum; above by the clavicle; and below by the diaphragm. It is destined to lodge and protect the chief organs of respiration and circulation:—the lungs and heart.

Thoracic.—Belonging to the thorax.

Tibia.—Latin. A flute. The largest bone of the leg is so called.

Tissue.—From the Latin, *texere*, to weave. The interlacement or union of many things which form a body, as threads of flax, silk, wool, &c., of which cloths and stuffs are made. From analogy, the term is employed in anatomy to describe the *substances* of which the organs of animals in general, and of man particularly, are formed, and which result from the interlacement of fibres. It is applied to the different kinds of organization of the body, as, for example, the *muscular* tissue,

osseous tissue, meaning the structure of which the muscles, and bones are composed.

TRACHEA.—From the Greek, *trachus*, rough, and *arteria*, an artery, which is formed from *aer*, air, and *terein*, to keep. The canal which conveys the air to the lungs. The wind-pipe.

TRICUSPID.—From the Latin, *tres*, three, and *cuspis*, a point—having three points. The three valves situate in the right auriculo-ventricular opening of the heart are thus named.

TUNICA.—Latin. A tunic; a coat or covering of an organ.

TYMPANUM.—Latin. A drum. The drum of the ear.

TYMPANI.—(Genitive case of tympanum.) Of the drum of the ear.

ULNA.—The bone of the forearm, which forms the prominence of the elbow, during the flexion of that joint.

ULNAR.—Relating to the ulna.

UNGUIFORM.—From the Latin, *unguis*, a human nail, and *forma*, shape—Of the form of a nail.

VALVE.—From the Latin, *valvæ*, doors—a small door. Any membrane or doubling of membrane which prevents fluids from flowing back in the vessels and canals of the animal body.

VEIN.—The veins are vessels for the conveyance of black blood from all parts of the body to the heart. They are found wherever there are arteries.

VELUM.—Latin. A veil.

VENOUS.—Relating to the veins.

VENTRICLE.—From the Latin, *venter*, a belly. A name given in anatomy to various parts.

VERMIFORM.—From the Latin, *vermis* a worm, and *forma*, form. Worm-shaped.

VERMICULAR.—Belonging or relating to worms. The motion of the intestines is vermicular, that is, resembling that of a worm.

VARTEBRA.—From the Latin, *vertere*, to turn. This name has been given to each of the bones, which, by their union, form the vertebral or spinal column, vulgarly called the back-bone.

VERTEBRÆ.—The plural of vertebra.

VERTEBRAL.—Belonging to the vertebræ.

VISCID. } Glutinous; sticky; tena-
VISCOUS. } ceous.

VISCUS.—Any bowel or entrail, or internal part, as the heart, liver, lungs, pancreas, &c.

VISCERA.—The plural of viscus.

VITREOUS—Resembling glass—glassy.

ZOOLOGY.—From the Greek, *zôon*, an animal, and *logos*, a discourse. That part of natural history which treats of animals.

ZOOLOGIST.—One devoted to the study of zoology.

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TRACY'S ELEMENTARY ARITHMETIC, and TRACY'S SCIENTIFIC AND PRACTICAL ARITHMETIC, constitute a part of our educational series. These works are from the pen of a thorough, practical teacher, of long experience and eminent success, especially in the mathematical department. We therefore invite a critical investigation of their peculiar merits, with the fullest assurance that the result will be, their extensive introduction into the schools of our country. Space will not allow us, in this connection, to present all we desire; we therefore refer the inquirer to the works themselves, simply stating that we shall be happy to furnish teachers with copies for examination.

The design of the *more elementary treatise* is to lay a broad and deep foundation, on which may be reared a substantial superstructure. The exercises are therefore of an elementary character, but extensive and practical. A thorough investigation of the varied examples in Simple Arithmetic, presented in this book, must secure for the scholar of ordinary capacity a thorough acquaintance, not only with the nature of numbers in their elementary capacity, but with their application to the *practical* purposes of life.

The Scientific and Practical Arithmetic, although a work complete in itself, in every respect, has peculiarities not noticeable to any great extent in the primary work; its object being to apply the elementary principles therein developed, so as to secure, in all cases, the required result by the *most direct course*. The mode of dealing with figures here inculcated, inspires the scholar with activity of thought and execution, and consequently ready and accurate results. Instead of presenting full illustrations of what we here state, we refer the inquirer to the work of analysis by cancellation, as exhibited at page 81, and applied throughout the body of the work to all solutions naturally effected by the combined application of multiplication and

division; and especially to the *computation of exchanges* in the money, weight, or measure of different countries, as exhibited at pages 241–2–3–7, &c. The principle of cancellation, in itself considered, is of course no new thing; but its application as here presented, important though it is, we are confident, *cannot be found in any other system of Arithmetic extant.*

In the application of the roots to business purposes, other new features in arithmetical science, which both abbreviate and shorten the ordinary process, are presented. We say "new features;" by this we simply mean, new applications of principles previously well known. In conclusion, we would simply invite attention to the following notices of the works from those who have tested their merits; most of whom are practical teachers, of eminent success.

The *third number* of the series will be issued soon. It will contain much that is new and important, relative to commercial and other business transactions of life.

Dear Sir: —I have examined your Arithmetics, and am free to say I know of no better works extant. I am particularly pleased with the clearness with which principles are stated, and with the general arrangement of the work.

SAMUEL GLEN,
Principal of Parochial School in Twelfth street, N. Y.

Having examined the series of Arithmetics by C. TRACY, A. M., I think them in many respects superior to any others I have seen. The exercises of the "elementary" work are well calculated to make expert and ready arithmeticians; while its whole plan renders it a fit substitute for a more expensive work. The "Practical Arithmetic" contains much original matter, especially on the subject of cancellation. Its rules and principles are clearly expressed; its examples are copious, appropriate, and well arranged. The excellence of these works renders them worthy of extensive patronage.

HENRY KIDDLE,
Principal of Public School No. 2, New York.

——— By the application of the principle of cancellation throughout the series, the *shortest way* will be the ordinary method of the learner. The system is well adapted to make rapid and accurate arithmeticians, and eminently practical.

M. C. TRACY,
Principal of Mechanics' Institute, New York.

From the "Teachers' Advocate."

Mr. TRACY considers that the simple rules are most used, and urges the necessity of acquiring great familiarity and expertness in their use and application. His "elementary" work, therefore, contains extensive exercises for the slate. It is systematic and analytic; and many of the examples are made up from statistics occurring in commerce, practical economy, and science.

Of the "Scientific and Practical Arithmetic," the new and marked features are — a free and rational use of cancellation, an explanation of Proportion by agencies and results, and the application of the principle that the product of the roots of several numbers is equal to the root of the product of the same numbers.

These works are written by a skilful and eminently practical man, and are sufficiently extensive for all ordinary business purposes.

From Rev. Isaac Ferris, D. D., President of Rutgers Female Institute, N. Y.

It gives me pleasure to state that I have examined the New Series of Arithmetics by Mr. CALVIN TRACY, with attention and interest. His larger work, professing to be an improvement of a former edition, is worthy of the name. His plan is lucid, comprehensive, and practical; and the whole shows the successful teacher, of long experience. The results of years in teaching Arithmetic are here very happily presented.

From Professor A. Rand, Principal of Boys' Select School, No. 16 Thirteenth street, New York.

Mr. TRACY:

Sir — I have for some time used your system of Arithmetic with much satisfaction. I give it the preference on account of its general application of the principle of cancellation. When your former edition was out of print, or rather when I was erroneously informed that it was so, I was so unwilling to relinquish its use, that I sent to my former pupils, and bought up old copies to supply my classes.

☞ The testimony of Prof. Rand respecting the purchase of old copies, is not a solitary case; others testify to having done the same.

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We subjoin testimonials from numerous distinguished Teachers and others, who have practically tested their value as school-books.

From John M'Clusky, D. D., Principal of the Academy and Normal School, West Alexandria, Pennsylvania.

JUNE 23d, 1849.

Messrs. Grigg, Elliot & Co. — Having used R. M. Smith's Quarto Geography in the Academy of West Alexandria for some time, it gives me pleasure to recommend it to the attention of all Common District Schools, Academies, and even Colleges, as decidedly a work of great merit.

JOHN M'CLUSKY.

RICHMOND, November 13th, 1848.

Dear Sirs — I have devoted all my leisure to the books left with me. Smith's Common School Geography is the *best system I have ever examined.* I know of no book so well adapted *as* the American, to aid the instructor in teaching boys *to think* — without which there can be, in truth, no education.

Very truly yours,

R. N. FOX,

Teacher of Classical and Mathematical School, S. E. corner Capitol Square.

The following teachers in Richmond, Virginia, have also recommended and introduced R. M. Smith's Geography in their Schools and Academies.

H. PORTERFIELD TAYLOR,
Principal of Union Academy.

JUDITH A. BREEDEN,
Select School.

MISS AUSTIS MAGEE,	SUSANNAH H. BURTON,
E. G. STARKE,	CAROLINE H. GAY,
A. B. SMITH,	ELIZABETH L. READ,
ABIAH S. HILLER,	C. A. STANFIELD,
M. H. SMITH,	A. LYON,
MARY F. ANDERSON,	WILLIAM S. FISHER.

NORFOLK, VIRGINIA, Jan. 9th, 1849.

We have carefully and critically examined R. M. Smith's Geography, and give it a decided prefcrence over all other works of the kind, and have introduced it into our schools.

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W. S. FORREST,
WILLIAM WHITE,
E. G. NEWSUND,
ANN DORER,
HOPE BAIN,
ELIZA M. RAMSAY,
A. E. BROWN,
LAURA L. DANIEL,
Teachers.

PETERSBURG, VA., Nov. 3d, 1849.

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ABIGAIL ROCKWELL,
G. M. F. BASS,
Teachers.

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The Publishers ask the particular attention of all Teachers and School Directors to the following notices of this popular School-Book:

Certificate of Correctness, from the Department of State.

DEPARTMENT OF STATE,
Washington, Oct. 1, 1850.

This is to certify, that Joseph Bartlett Burleigh's Script Edition of the U. S. Constitution, with the Amendments, has been carefully collated with the originals in the Archives of this Department, and proved to be accurate in the *capitals*, *orthography*, *text*, and *punctuation*.

DAN. WEBSTER, Secretary of State.

W. S. DERRICK, Chief Clerk.

OFFICE OF THE CONTROLLERS OF PUBLIC SCHOOLS,
First School Dist. of Pennsylvania, Philada., Dec. 11, 1850.

At a meeting of the Controllers of Public Schools, First District of Pennsylvania, held at the Controllers' Chamber, on Tuesday, December 10th, 1850, the following resolution was adopted:

Resolved, That the American Manual, by J. Bartlett Burleigh, be introduced as a class-book into the Grammar Schools of this District.

ROBERT J. HEMPHILL, Secretary.

This book has also just been introduced into the Public Schools of Washington, D. C.

ALLEGHANY CITY, May 31, 1849.

Having examined the American Manual, by J. B. Burleigh, and having used it as a text-book in our classes in the Public Schools of this city, we think it a work of superior merit. The subject, the style, the marginal exercises, the questions at the foot of each page, the appendix, and the statistical tables, are such as to make the work complete. In the hands of the judicious teacher, it will be found *the very book* needed.

J. A. COVELL,	A. T. DOUTHETT,
E. FRAZIER,	JNO. STERRITT,
M. WILSON,	WM. M. HASTINGS,
JAS. B. D. MEEDS,	LEONARD H. EATON,

Principal of 2d Ward Boys' School, Pittsburg.

JAMES ANDERSON, *Principal of Pittsburg Academy, and many other Principals of Schools and Academies.*

(COPY.)

At a meeting of the Board of School Commissioners of the city of Wheeling, Va., held at the court-house, June 14th, 1849, the following resolution was adopted unanimously:

Resolved, That the American Manual, by Jos. Bartlett Burleigh, be and the same is hereby adopted as a text-book, to be used in the Public Schools of this city.

Attest, GEORGE W. SIGHTS,
Clerk of Board of School Commissioners.

PITTSBURG, June 5th, 1849.

We, the undersigned, Teachers in the Public Schools of Pittsburg, have used Burleigh's American Manual with great satisfaction and delight. The plan of the work is in all respects judicious. The marginal exercises are a novel and original feature. They are arranged with great accuracy and discrimination. Their use not only excites the liveliest interest among the pupils, but produces great, salutary and lasting effects in arousing the mental powers, and leading the scholars constantly to investigate, reason, and judge for themselves. The Manual is elegantly written, and must have the effect to give a taste for what is pure and lofty in English literature. Throughout the entire work, the strictest regard is inculcated for the purest morality.

B. M. KERR, SAMUEL C. HARPER,
J. WHITTIER, M. H. EATON,
N. VERNON,

Prof. of Mathematics and English Literature in Frederick College. And many other Principals of Schools and Academies.

Extract of a Letter from Wm. Roberts, Esq., President of the Board of School Commissioners of Princess Anne county, Virginia.

NEWTOWN, Princess Anne Co., Va., July 27, 1849.

The Board of School Commissioners, of this county, held a meeting about three weeks ago, and passed a resolution that the American Manual be introduced into our schools. The popularity of the Manual, upon examination by so large a number of our citizens, almost surprises me; for not only the School Commissioners have read it, but a great number of our citizens. I consider it the best book for training the young mind, in the earlier stages of its education, I have ever seen."

(COPY.)

BALTIMORE, October 5th, 1848.

The American Manual, by Joseph Bartlett Burleigh, A. M., has been introduced by the Commissioners of the Public Schools into the Central High School, and the two Female High Schools of Baltimore.

J. W. TILYARD,
Clerk of Commissioners of Public Schools

BALTIMORE, March 14th, 1849.

This is to certify, that the Board of Commissioners of the Public Schools for Baltimore county have adopted the American Manual, by J. B. Burleigh, as a text-book, to be used in the schools under their direction. This Board has under its control over sixty schools located throughout Baltimore county.

WILSON C. N. CARR,
Clerk to the Board of School Commissioners for Baltimore county.

Extract of a Letter from Leroy G. Edwards, Esq., President of the Board of Public School Commissioners for Norfolk county, Virginia.

I consider the American Manual a desideratum which had not before been supplied, and respectfully recommend that it be used generally in every *District Free School in this county.*

Extract of a Letter from John B. Strange, A. M., and R. B. Tschudi, A. M., Principals of the Norfolk Academy, Virginia.

We do not hesitate to pronounce it (the American Manual) one of the best School-Books we have ever examined, not only as regards the matter, but also the manner of communicating it. The Manual is adapted to the capacity of the youngest, and must prove highly interesting and instructive to the oldest pupils. It communicates information which every American should possess, in a style so clear, and by a plan so admirable, that the work must commend itself to all who become acquainted with its merits. We shall introduce it into this institution, and hope that the schools throughout the country will not fail to appreciate its worth, and adopt it at the earliest moment as one of their text-books.

Extract of a Letter from Hon. Colman Yellot.

I sincerely hope that the American Manual may become a standard text-book in all our schools. But it is a work designed not merely for the perusal of the young. Its peculiar beauty of style, and the great amount of useful information collected in so convenient a form, should render it a favourite book of reference for the legislator, the politician, and the general reader.

Extract of a Letter from Alexander Campbell, D. D., LL. D., President of Bethany College, Virginia.

The American Manual is an admirable text-book for teacher and pupil, on the various important subjects so essential to the American scholar and statesman.

(COPY.)

STEUBENVILLE, OHIO, May 17th, 1849.

Messrs. Grigg, Elliott & Co.—We, the undersigned, Teachers of the Public Schools in the city of Steubenville, find, on trial, that Burleigh's American Manual is the *best book* with which we are acquainted for waking up the mind of youth, for training them to understand what they read, for leading them to investigate and reason for themselves; thereby thoroughly

fitting them for the duties of after life. The school, the infallible test of the merits of a class-book, proves that its proper use need only be witnessed to receive the approbation of every friend of thorough education.

M. A. WALKER,	WM. M'CAY,
M. KIDDO,	FRANCIS TURNER,
M. HULL,	I. B. BUTLER,
J. BROWN,	E. KELL,
M. ALLEN,	M. ORR.

Extract of a Letter from the Hon. B. Everitt Smith.

I doubt whether the ingenuity of man can ever devise a work better adapted to the purpose avowed by the author. I arose from the perusal of the American Manual, more deeply impressed than ever with my responsibility as a citizen, and with the absolute importance of fostering sound virtue and political morality.

From L. T. Cowell, Esq., late Teacher of Mathematics, Ypsilanti Seminary, Michigan.

Having carefully examined the American Manual, by President Burleigh, A. M., and having used it as a text-book (the best test of its merits), I deem it a work of superior merit. As a Commentary on the Constitution of the United States, it is of *high intrinsic worth.* The directions upon the method of instruction — the subject, the style, the marginal exercises, the appendix (a key to the whole work), the statistical tables, and the questions at the foot of each page, fully meet the wants of the pupil and teacher. The points treated of, the language, and the plan of the work, make it complete. It is of the highest order. Its *merits* commend it to universal approbation.

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This work contains, among other very important improvements, Questions on the Rules and Theory of Arithmetic, which are considered, by Teachers generally, very conducive to the improvement of the pupil. Although a prejudice exists among some Teachers in favour of the old works on Arithmetic, yet the very liberal patronage which this work has received, must be considered as decisive evidence of the high estimation in which it is held by most of the instructors of youth. Upwards of

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have been printed and sold. The sums being altogether in Dollars and Cents, gives it a decided preference over any other Arithmetic in use. The most distinguished Teachers in our city pronounce it superior to any other similar work; therefore the publishers sincerely hope this useful improvement will overcome the prejudice that many teachers have to introducing new works — particularly those preceptors who wish to discharge their duty faithfully to parent and child.

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C. W. HACKLEY, D. D.,
Professor of Mathematics and Astronomy in Columbia College.

I have examined a set of plates about to be published by Lippincott, Grambo & Co., and believe that they may be very useful in illustrating the elementary principles of Natural Philosophy.

JAMES RENWICK,
Prof. of Natural and Experimental Philosophy in Columbia College.

I have examined the Philosophical Diagrams prepared by Dr. Mayo. They are, in my opinion, very accurate and well arranged, and cannot but prove highly useful for elementary instruction in the various branches of Natural Philosophy. It affords me pleasure to recommend them.

HORACE WEBSTER, LL. D.,
President of the New York Free Academy.

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In giving the above extract, we take occasion to say, that Teachers will find the "Ladies' and Gentleman's Lexicons" admirably adapted to take the place, with advantage to their pupils, of the different works recently put into their hands under the name of Expositors, &c.

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